Evaluation of the NEMO model of the Fraser River plume in the Strait of Georgia

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Committee members: Susan, Rich, Nancy, Mark
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Contents

My background

Course	Name	Session	Credits	Status
EOSC 512	Advanced Geophysical Fluid Dynamics	2014W Term 1	3.0	Completed
EOSC 516	Teaching and Learning in Earth, Ocean and Atmospheric Sciences	2014W Term 1	2.0	Completed
EOSC 571	SEM PHYSICAL OCGY	2014W Term 1 & 2	3.0	Completed
EOSC 579	Dynamic Oceanography	2014W Term 2	1.0	Completed
EOSC 573	Methods in Oceanography	2014W Term 2	3.0	Completed
EOSC 576	Tracers in the Ocean	2014W Term 2	3.0	Completed
EOSC 511	Numerical Techniques for Ocean, Atmosphere and Earth Scientists	2015W Term 1	3.0	Undergoing

TA course	Name	Session
EOSC 211	Computer Methods in Earth, Ocean and Atmospheric Sciences	2014 W Term 1
EOSC 112	The Fluid Earth: Atmosphere and Ocean	2014 W Term 2

Research Questions

- **Goal**: Test and evaluate river treatments for Fraser River as well as other external forcing factors, such as tides and winds, to acquire more accurate plume properties in nowcast and forecast model results and better simulate surface currents in the Fraser River plume.

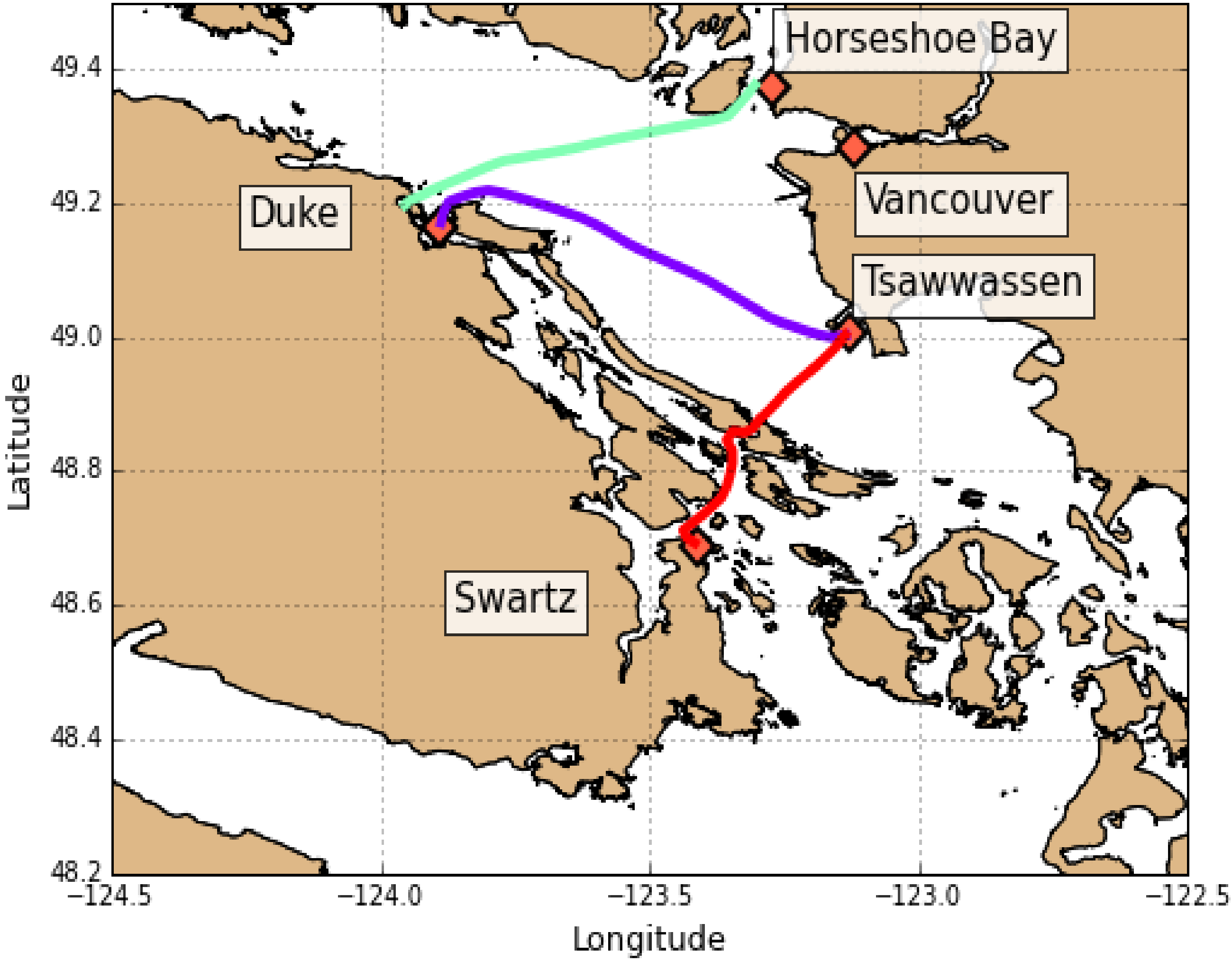
- What kind of available data, of what time scale and space scale, can be used to evaluate plume results? How well does the model reproduce the results?

- What is the geometry of the Fraser River that should be added into the NEMO model? How sensitive are salinity and surface currents in the plume to the geometry of Fraser River estuary and region around mouth?

- How do different parameters affect plume properties, for instance, surface salinity and surface currents?

Model-Data Comparison

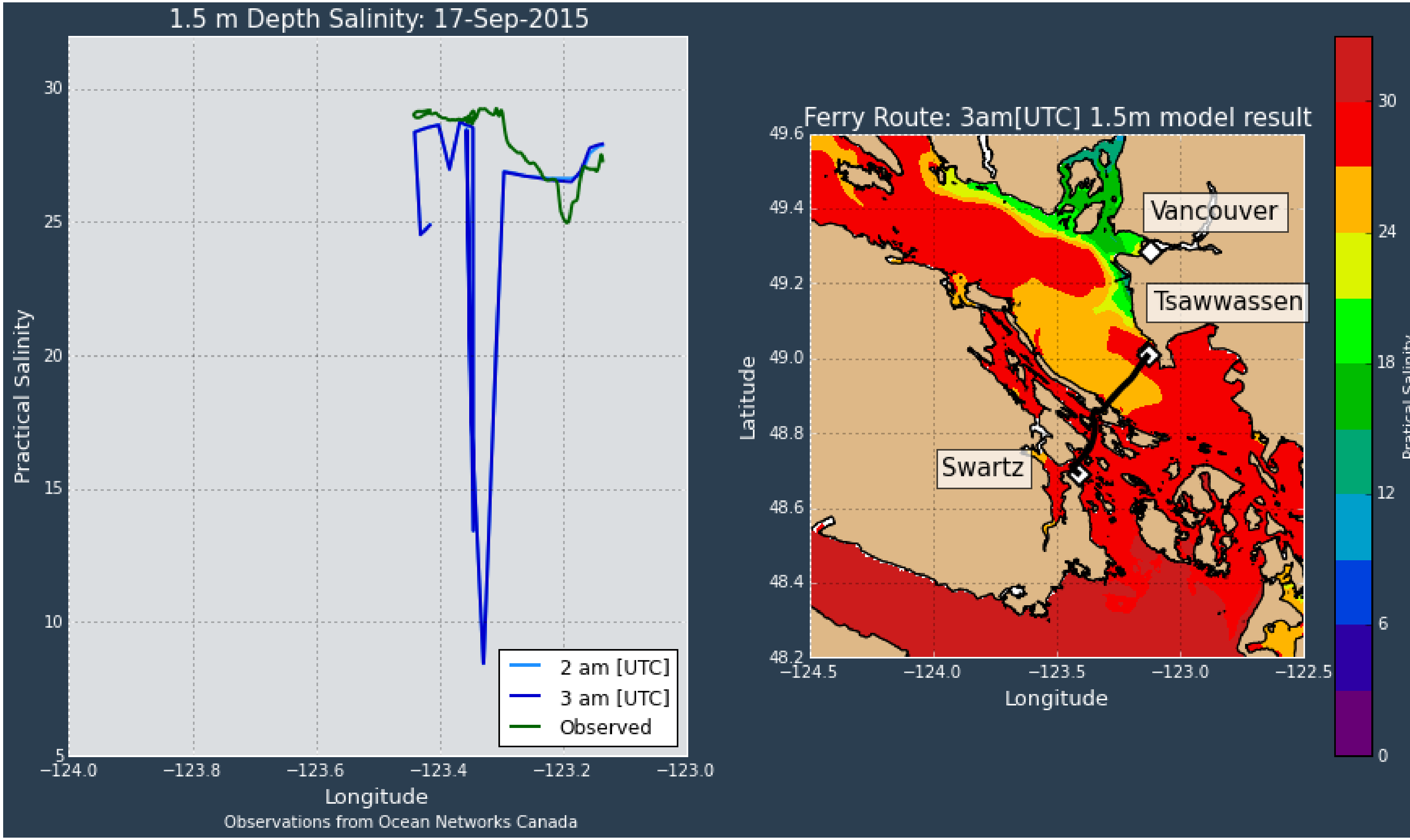
☐ Ferry-based observational data



☐ VENUS (Ocean Networks Canada)

- ➢ Tsawwassen to Duke Point
- ➢ Nanaimo to Horseshoe Bay
- ➢ Tsawwassen to Swartz

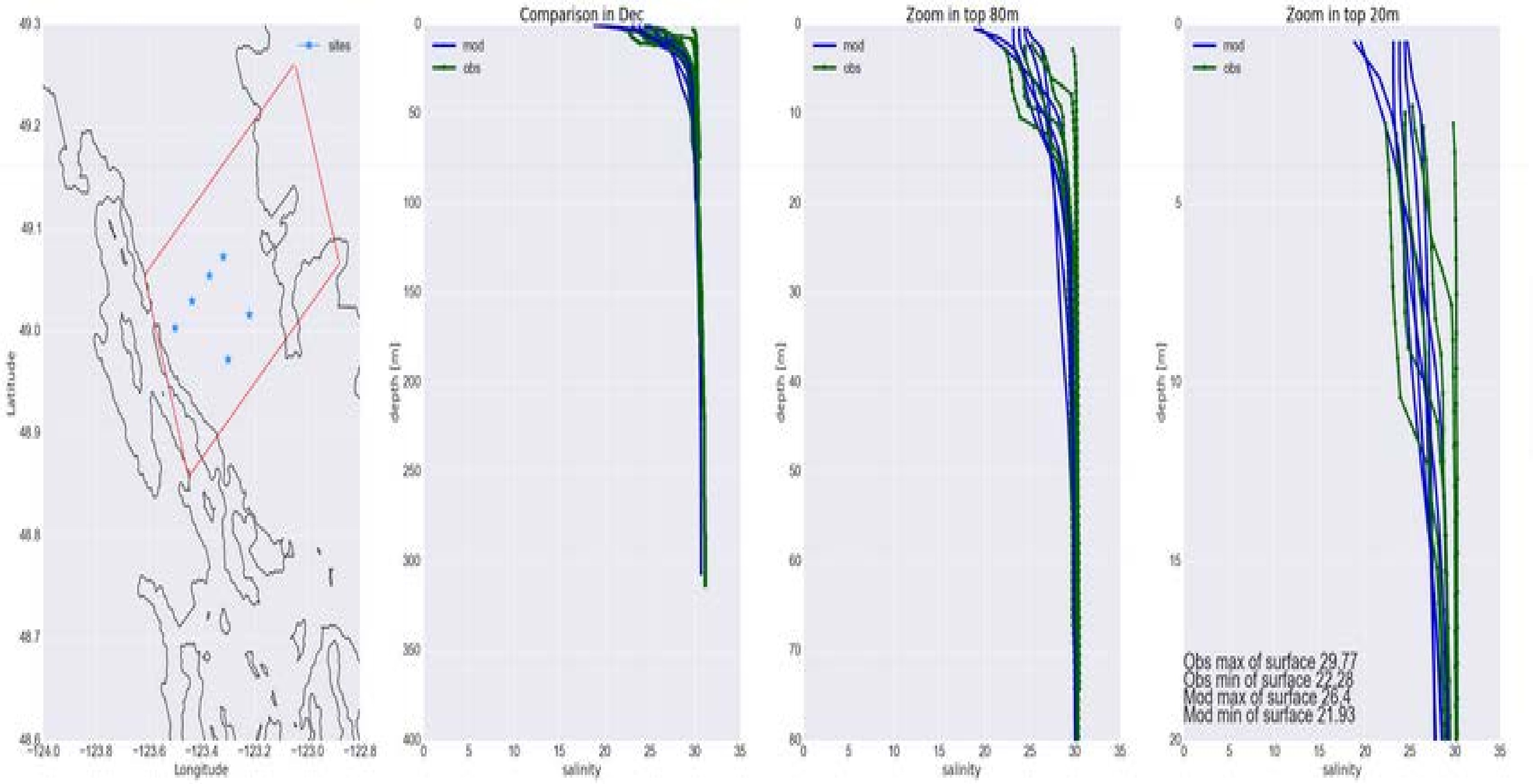
Data-model comparison



Data-model comparison

- ➢ On average, surface salinity is in appropriate range.
- ➢ Intermediate salinity is too fresh.
- ➢ Comparison limited by model and observation dates.

◻ CTD profiler data

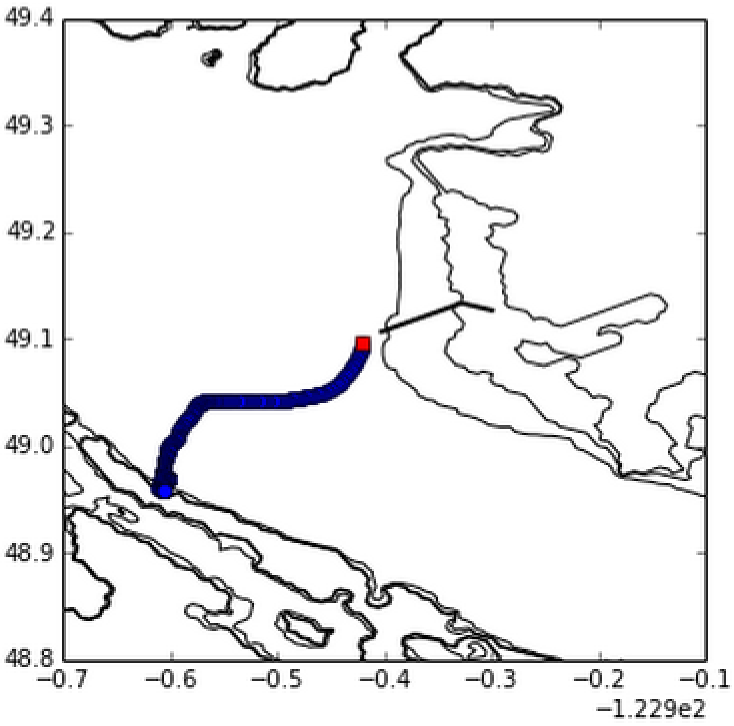


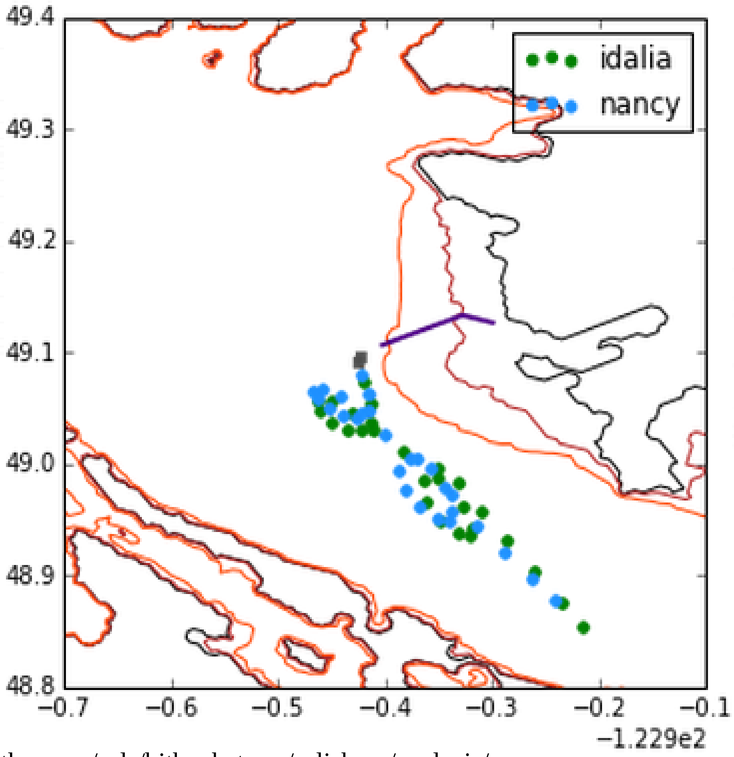
Data-model comparison

- Total 9 drifters.

◻ Drifter data

- Released on Oct 8, 2014 at 16:00, 16:05, 16:10, 17:30(twice), 17:35, 19:10, 19:20(twice) respectively.



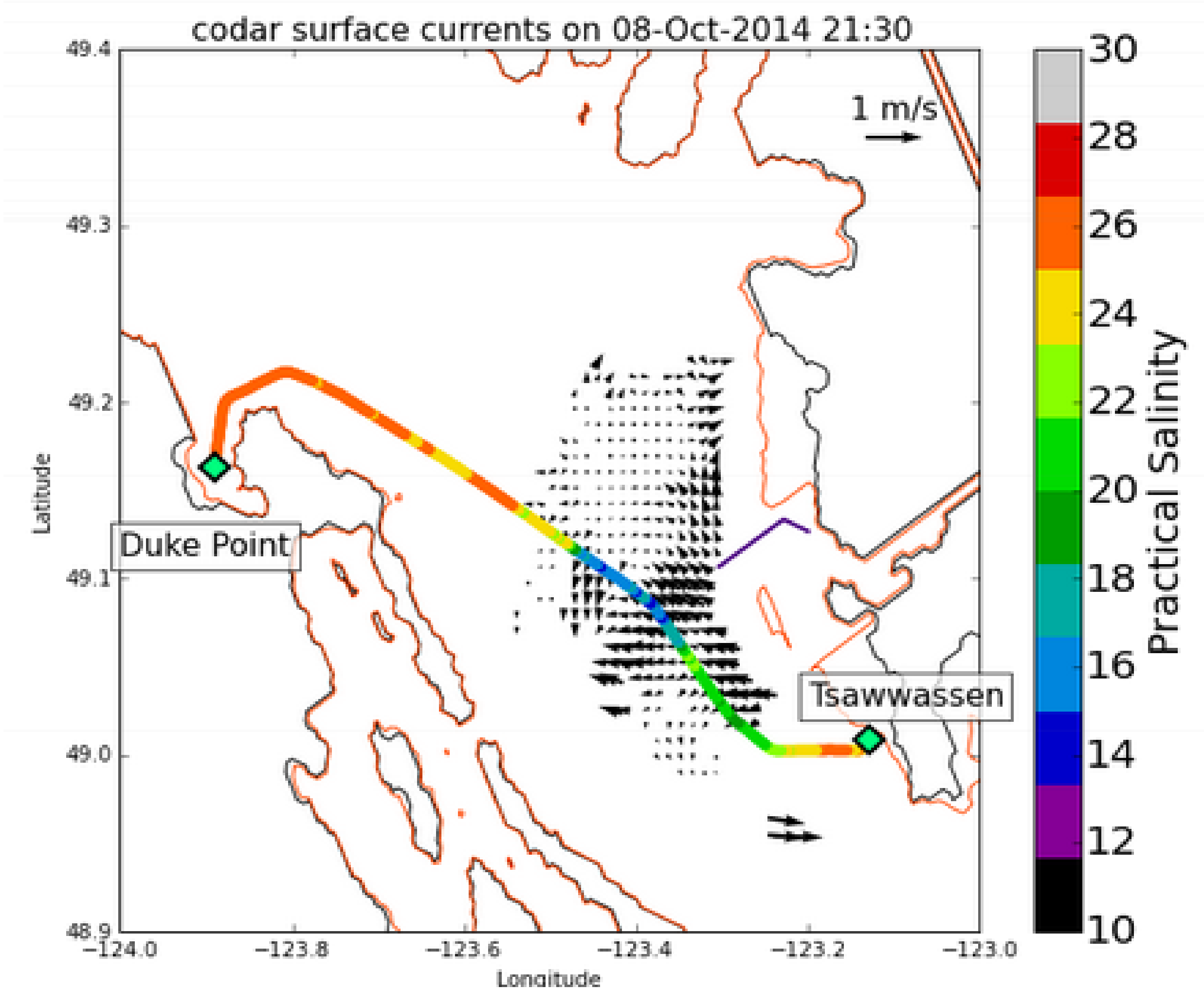


http://nbviewer.ipython.org/urls/bitbucket.org/salishsea/analysis/raw/tip/Nancy/drifters/Drifters_Ariane_Comparison_Nancy.ipynb

- Surface currents need to be improved.
- Tides in the model are too strong.
- Cross-strait flow is too weak.

Data-model comparison

◻ CODAR data



- ➢ Start to look at flow structure.
- ➢ Mark’s tidal analysis confirm drifter interpretation.

Problems for plume results:

How to improve surface currents in the plume?!

1

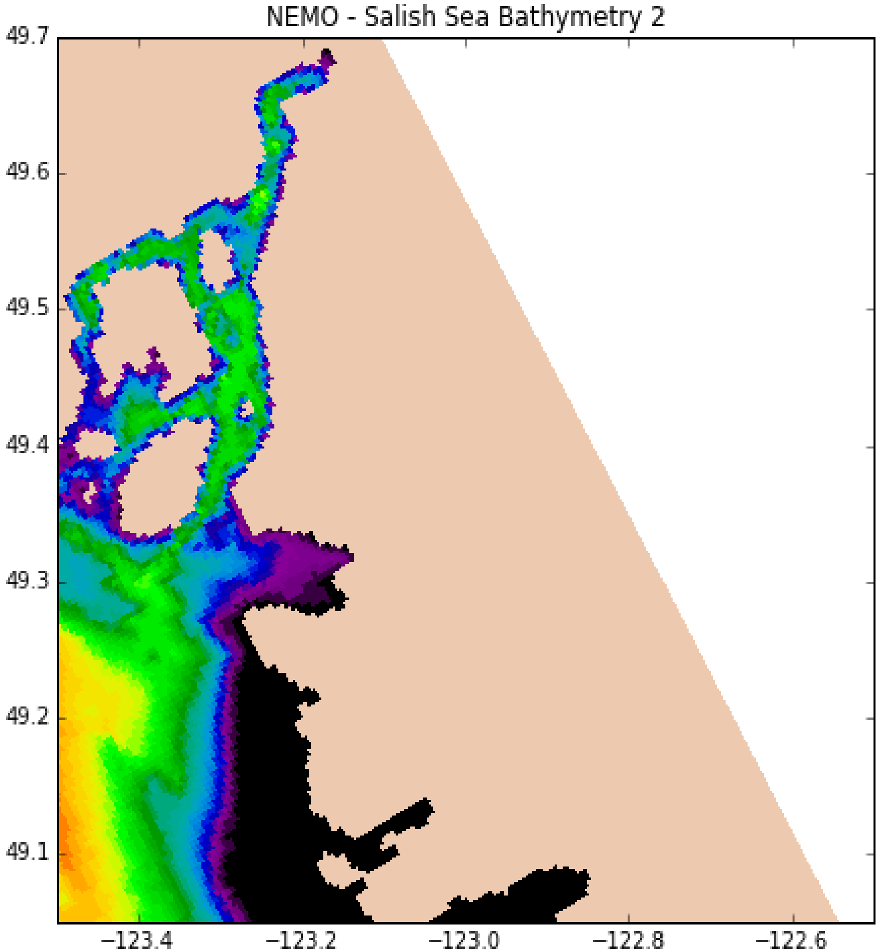
- Too weak cross strait velocity in the model.

2

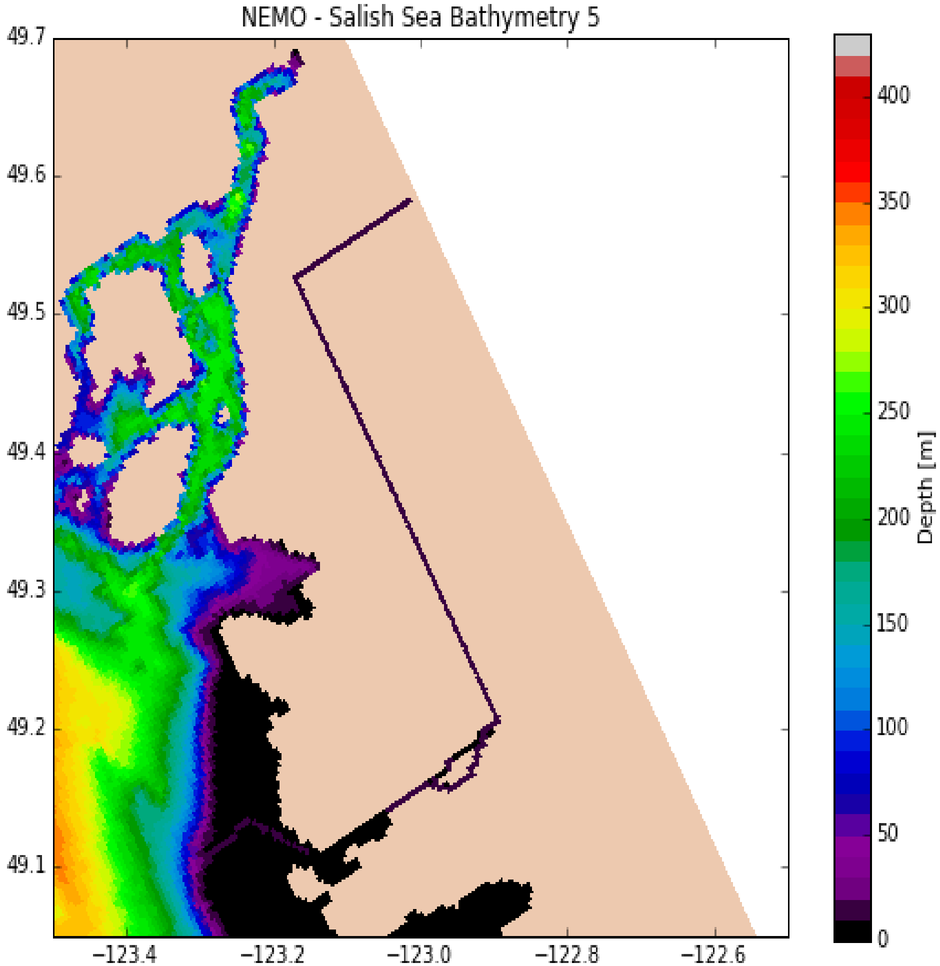
- Position northward shift for plumes in the model.

Test Various River Treatments

- Hypothesis 1: Too short river channel



➢ Original river channel for Fraser: **bathymetry 2**



➢ Extended river channel for Fraser: **bathymetry 5**

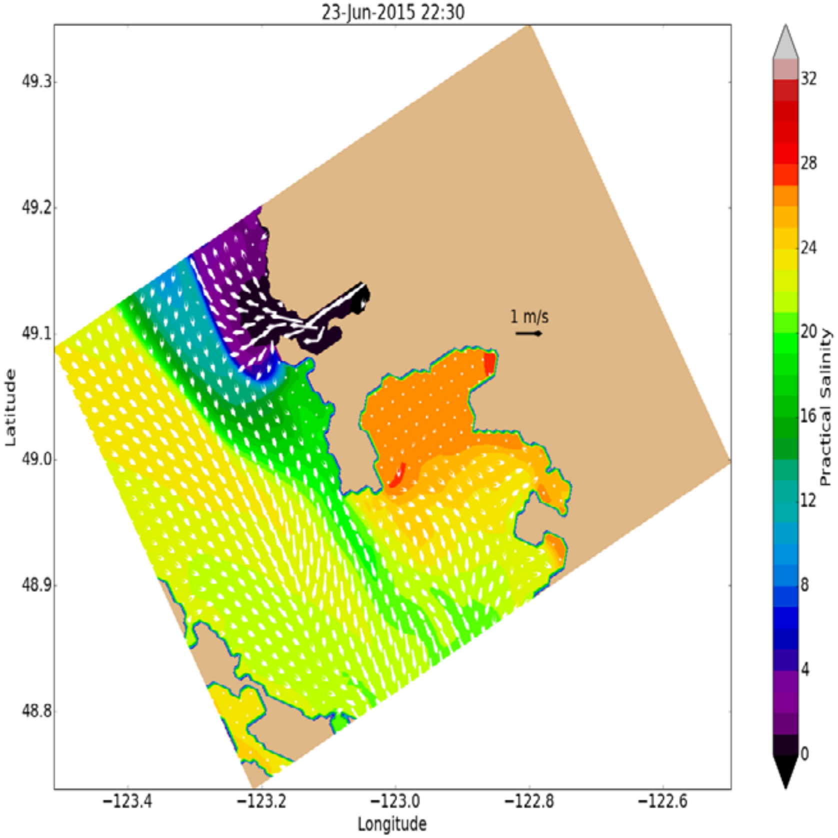
Test Various River Treatments

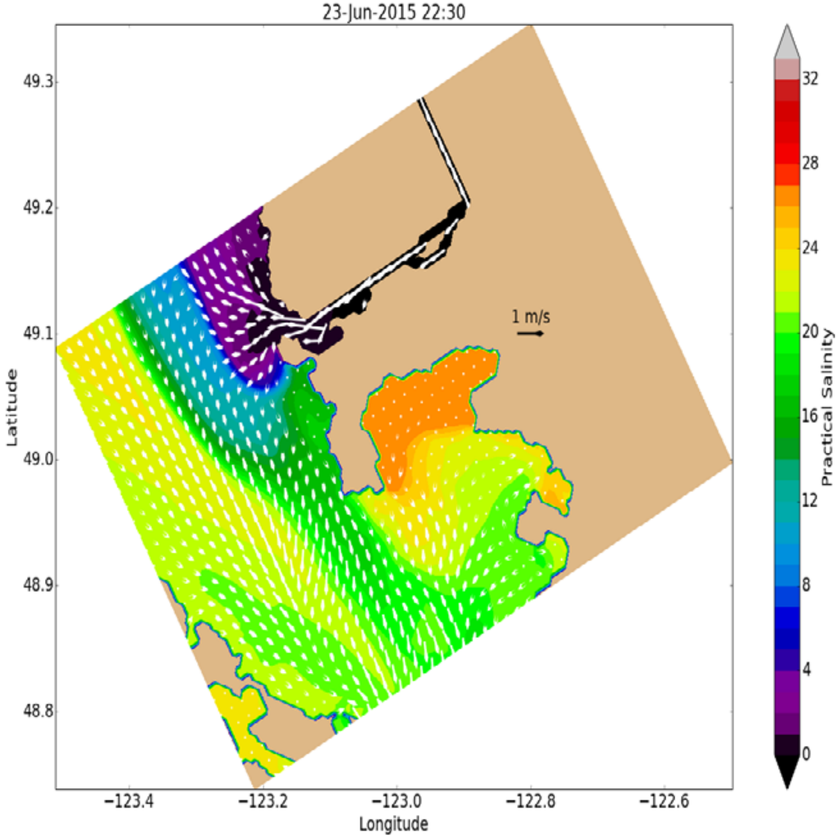
▫ Model configuration for sensitivity experiments:

- **NEMO 3.4** version.
- **Smoothed bathymetry 5** that includes a 'long' river channel to the east.
- Minimum depth is set to 4 m, **no wetting and drying**.
- Temperature, salinity initial conditions: **T** for new channel of **14° C**
  S after New Westminster as **0**, before as **4**.
- Model forcing: **Climatology river runoff** of Fraser.
  8 tidal constituents forced the boundary.
  Daily operational model winds.
- Parameters: background **vertical eddy viscosity** $1\times10^{-4} m^{2} s^{-1}$
  background **vertical eddy diffusivity** $1\times10^{-5} m^{2} s^{-1}$

Test Various River Treatments

- **Sensitivity experiment with bathymetry 5:**



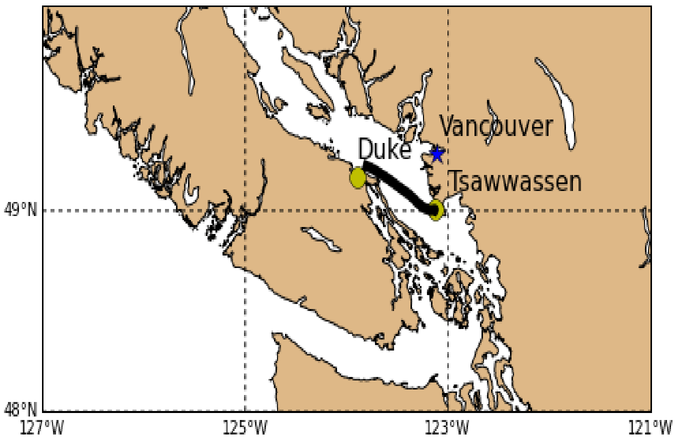


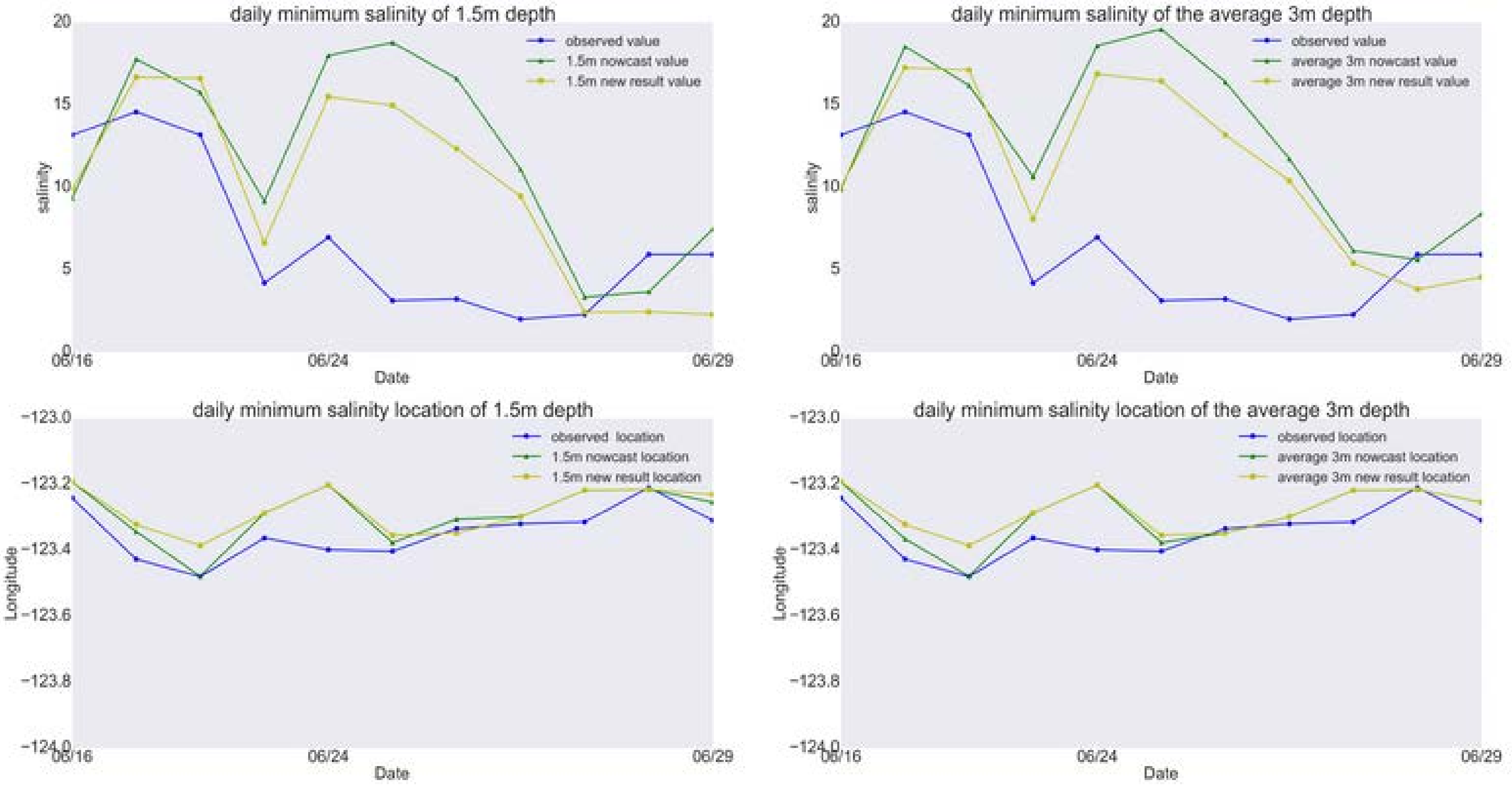
- Model nowcast results from June 15 to June 29, 2015

- 7 days simulation run on June 23, 2015

Test Various River Treatments

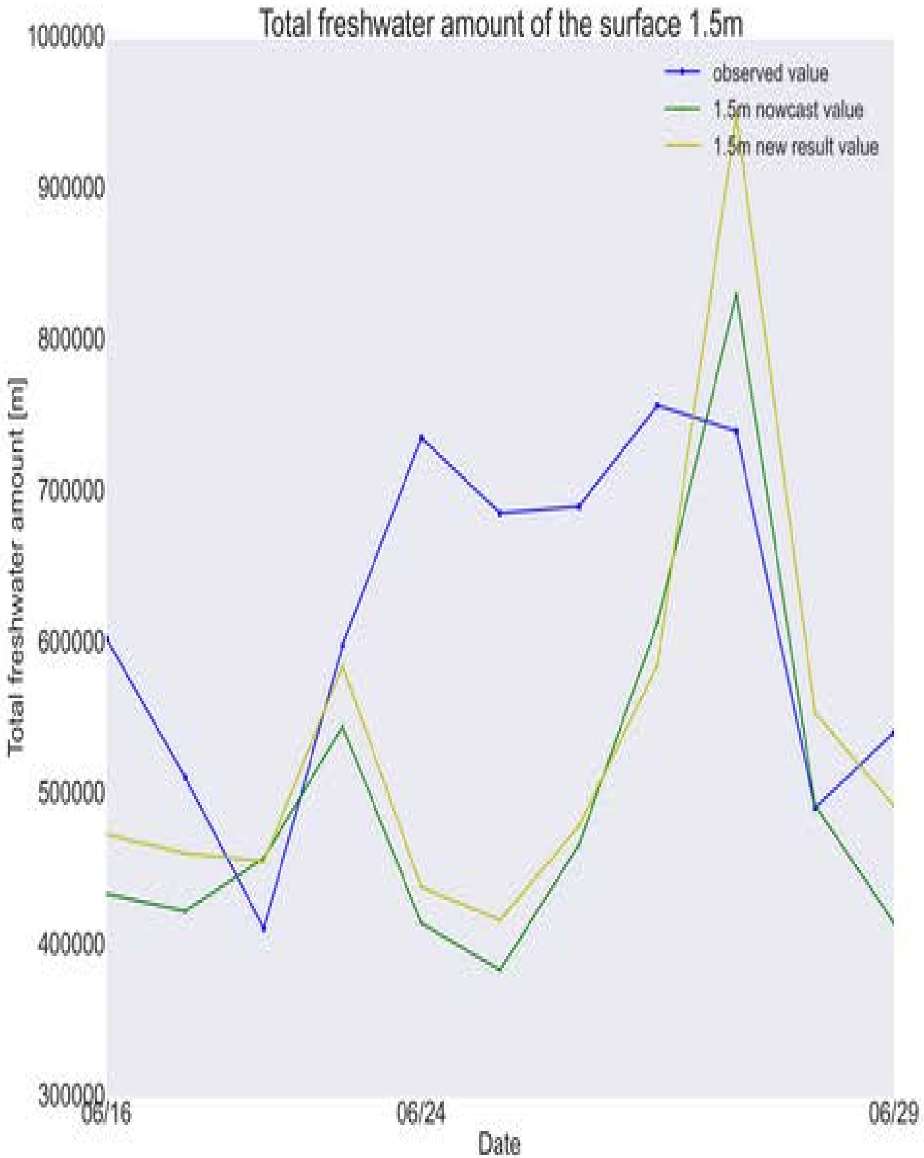
- Minimum salinity value/location

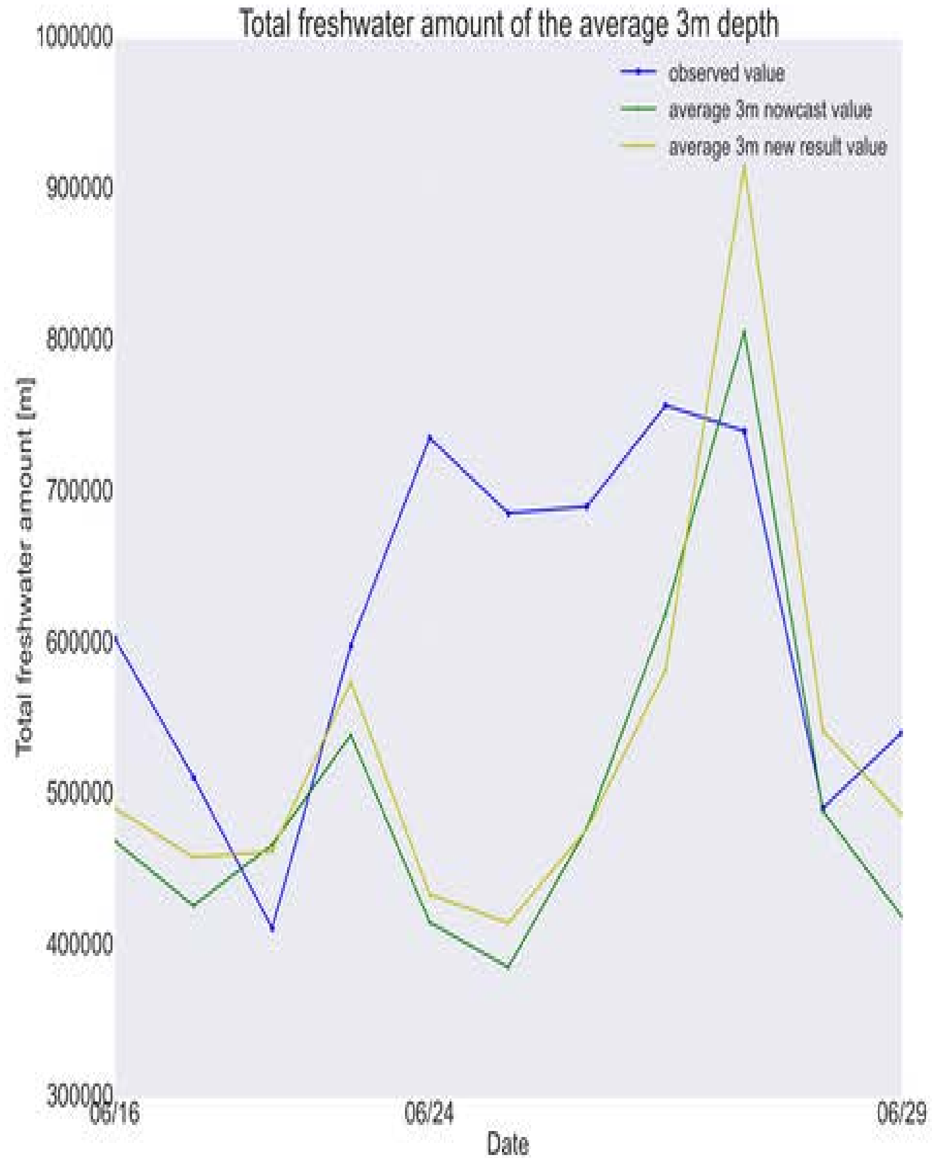




Test Various River Treatments

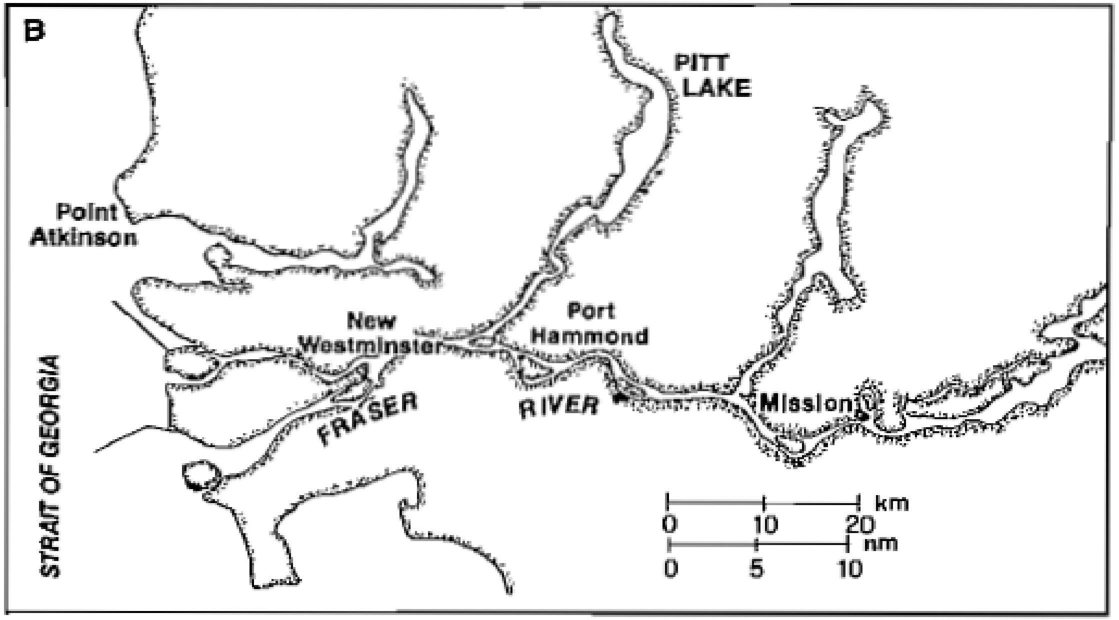
- Freshwater amount along ferry route





Test various River Treatments

- Tidal heights along Fraser River channel for bathymetry5



- Water level = Tidal height + height caused by river discharge

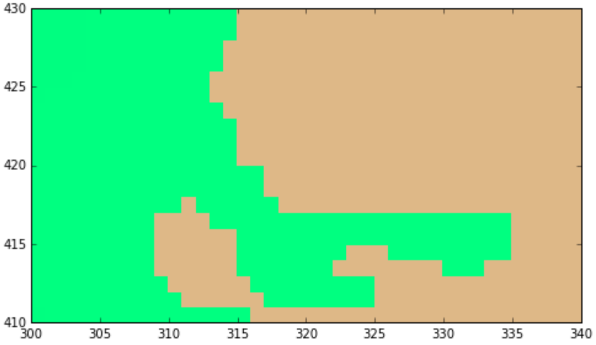
Map of river(Ages and Woollard 1976)

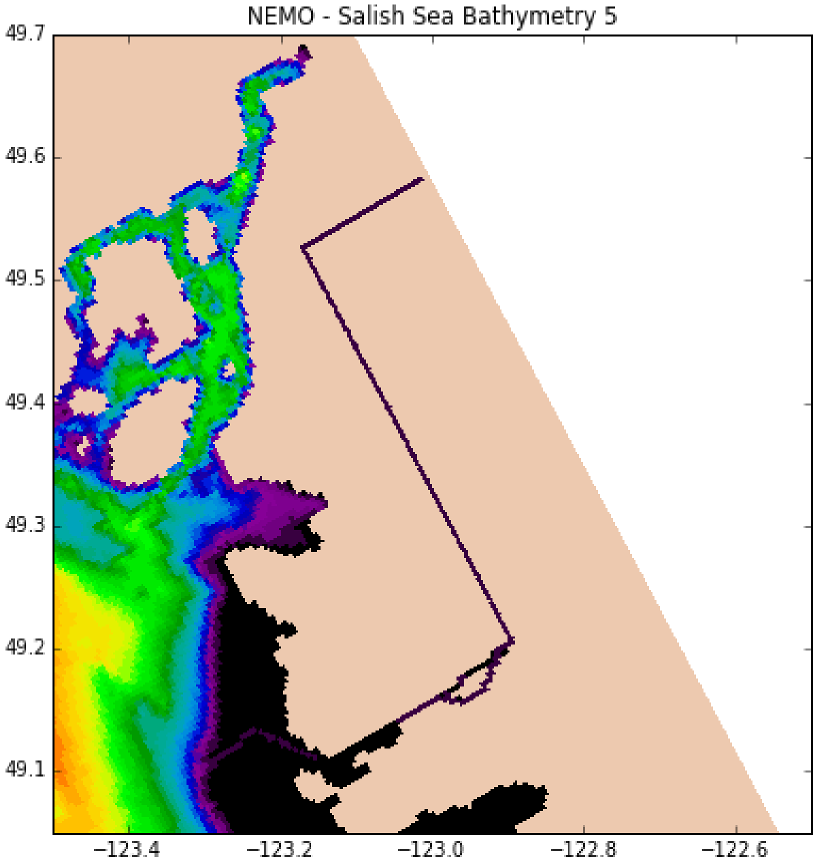
Table 2.1: Tidal amplitude comparisons inside Fraser River between extended river channel and observations

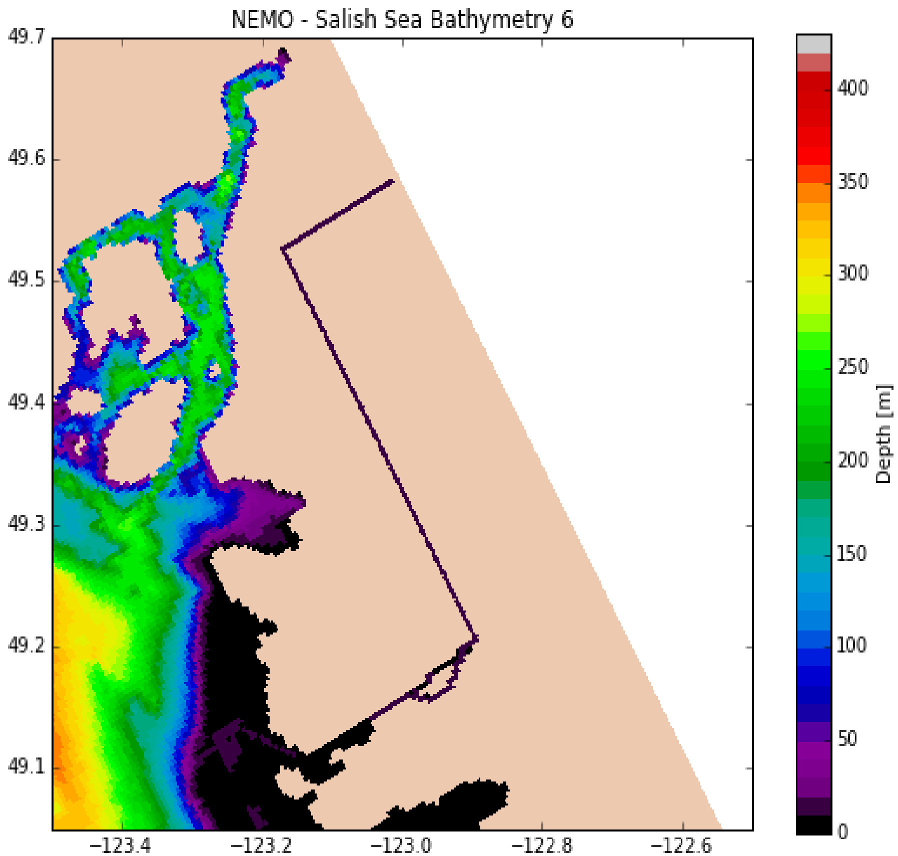
Tidal amplitude							
Station Names	Distance from mouth[km]	Observed Max Amplitude[m]	Observed Min Amplitude[m]	Observed Mean Amplitude[m]	Model Produced Max Amplitude[m]	Model Produced Min Amplitude[m]	Model Produced Mean Amplitude[m]
Steveston	1	3.49	2.10	2.88	3.73	2.03	2.91
Deas Island Channel	18	3.05	1.85	2.58	1.46	1.01	1.27
New Westminster	36	2.28	1.43	1.91	0.84	0.57	0.71
Mission	52	0.37	0.24	0.31	0.84	0.57	0.70

Test Various River Treatments

- **Hypothesis 2: Too shallow river channel around the mouth**







- Extended river channel for Fraser: **bathymetry 5**

- Extended and deepened river channel for Fraser: **bathymetry 6**

Test Various River Treatments

◻ Tidal heights along Fraser River channel for bathymetry6:

Table 2.2: Tidal amplitude comparisons inside Fraser River between deepened river channel and observations

Tidal amplitude							
Station Names	Distance from mouth[km]	Observed Max Amplitude[m]	Observed Min Amplitude[m]	Observed Mean Amplitude[m]	Model Produced Max Amplitude[m]	Model Produced Min Amplitude[m]	Model Produced Mean Amplitude[m]
Steveston	1	3.49	2.10	2.88	3.72	2.03	2.89
Deas Island Channel	18	3.05	1.85	2.58	3.55	2.04	2.80
New Westminster	36	2.28	1.43	1.91	3.02	1.78	2.42
Mission	52	0.37	0.24	0.31	3.00	1.71	2.37

➢ Further tuned bathymetry after New Westminster to 8m, modelled mean amplitudes for these stations are: **2.895m, 2.803m, 2.383m, 1.231m**.

➢ Finally, tuned bathymetry after New Westminster to 3m, modelled mean amplitudes for these stations are: **2.897m, 2.864m, 2.602m, 0.186m**.

Test Various River Treatments

- bathymetry 10 (with jetty):

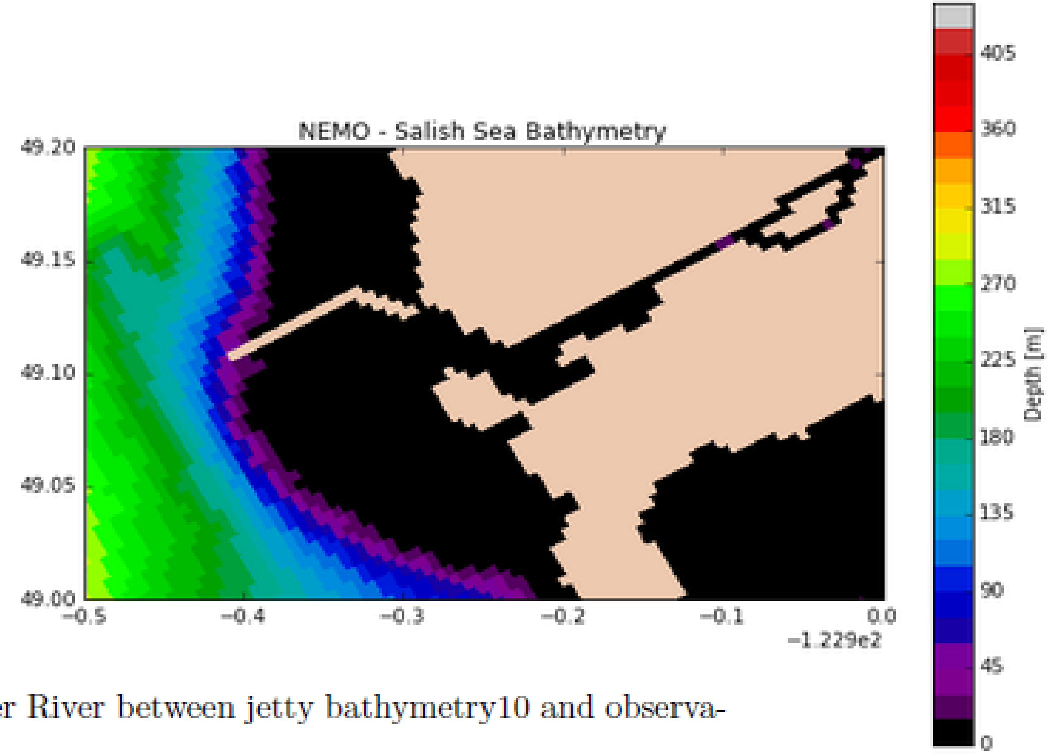
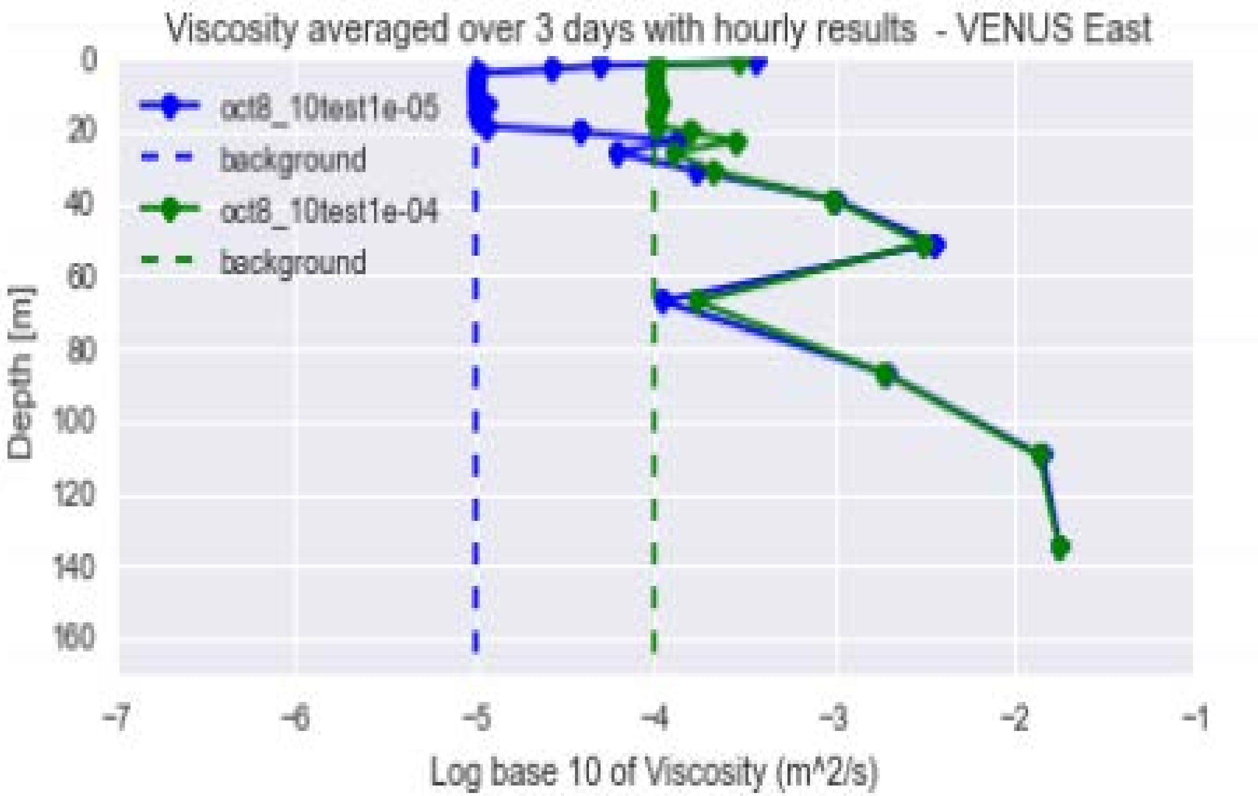


Table 2.4: Tidal amplitude comparisons inside Fraser River between jetty bathymetry10 and observations

Tidal amplitude							
Station Names	Distance from mouth[km]	Observed Max Amplitude[m]	Observed Min Amplitude[m]	Observed Mean Amplitude[m]	Model Produced Max Amplitude[m]	Model Produced Min Amplitude[m]	Model Produced Mean Amplitude[m]
Steveston	1	3.49	2.10	2.88	3.70	2.0	2.93
Deas Island Channel	18	3.05	1.85	2.58	3.57	2.06	2.88
New Westminster	36	2.28	1.43	1.91	3.31	2.0	2.683
Mission	52	0.37	0.24	0.31	3.36	2.05	2.766

Hindcast comparison

◻ background eddy viscosity & diffusivity



- ➢ lower background eddy viscosity from 1e-04 to 1e-05 m2/s
- ➢ lower background eddy diffusivity from 1e-05 to 1e-06 m2/s

Hindcast comparison

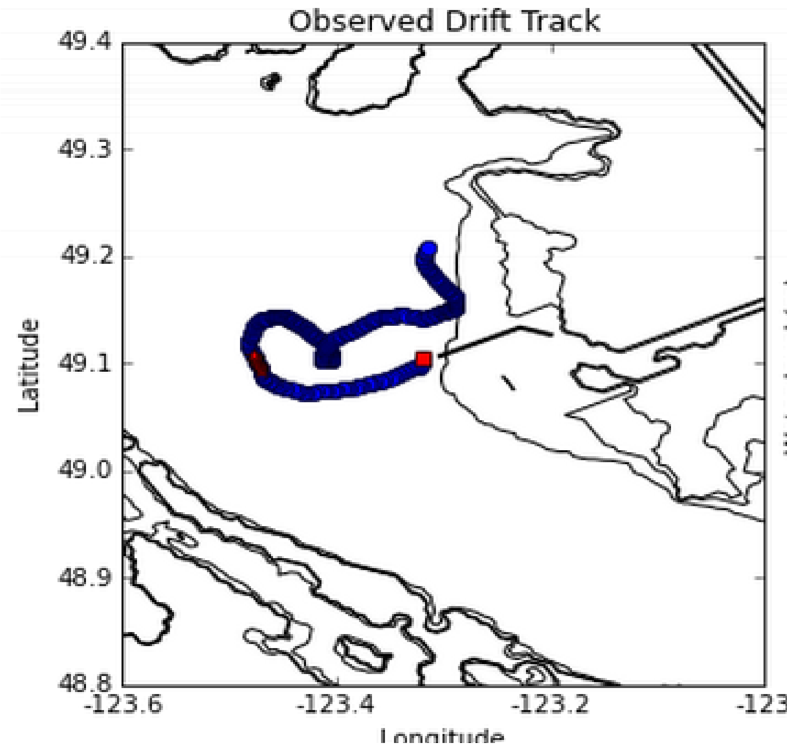
- Five modelled cases to compare with drifter data:

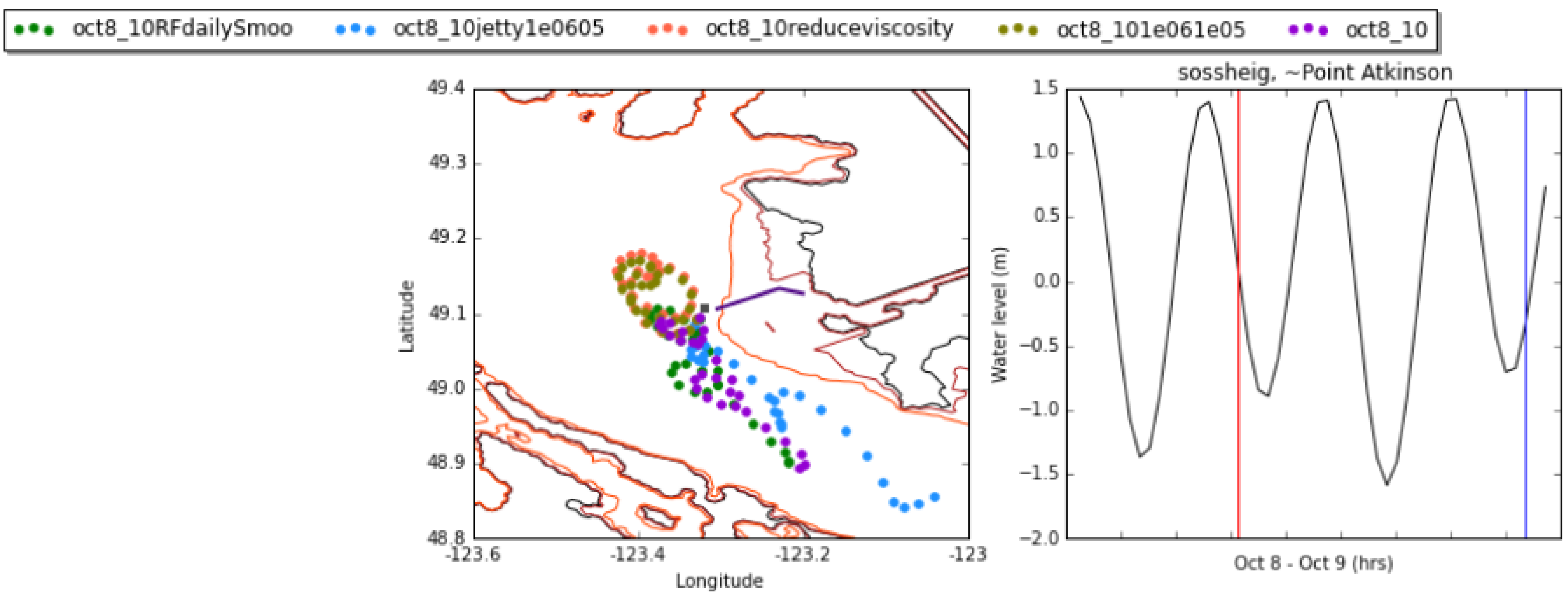
- Original nowcast results.
- New results with bathymetry 6.
- New results with bathymetry 6 with reduced background eddy viscosity to 1e-05.
- New results with bathymetry 6 with reduced background eddy viscosity to 1e-05 and background eddy diffusivity to 1e-06.
- New results with bathymetry 10 (jetty) with reduced viscosity and diffusivity.

- Spin-up days: Sep 25- Oct 7, 2014
  Simulation days: Oct 8- 10, 2014

Hindcast comparison

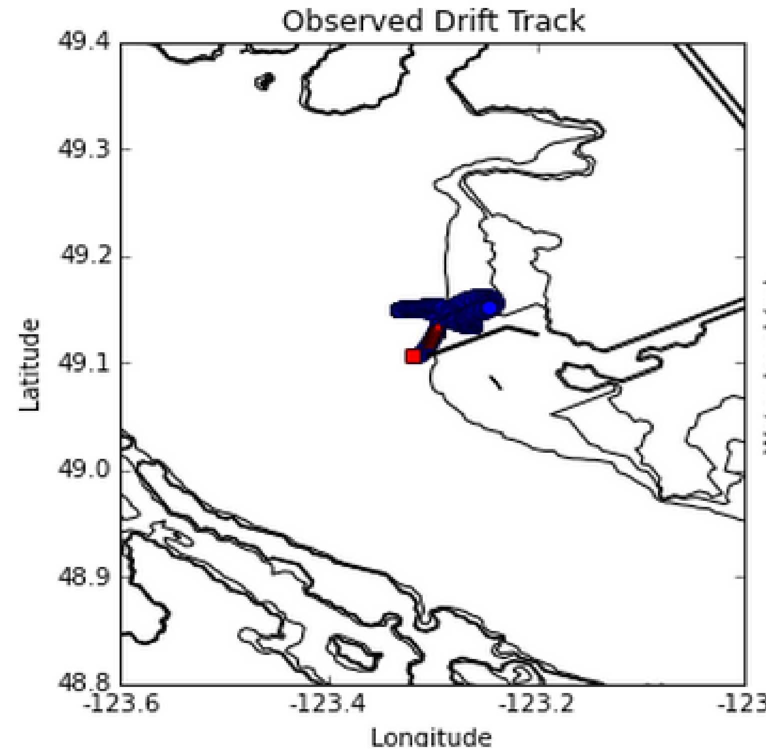
- Drifter1

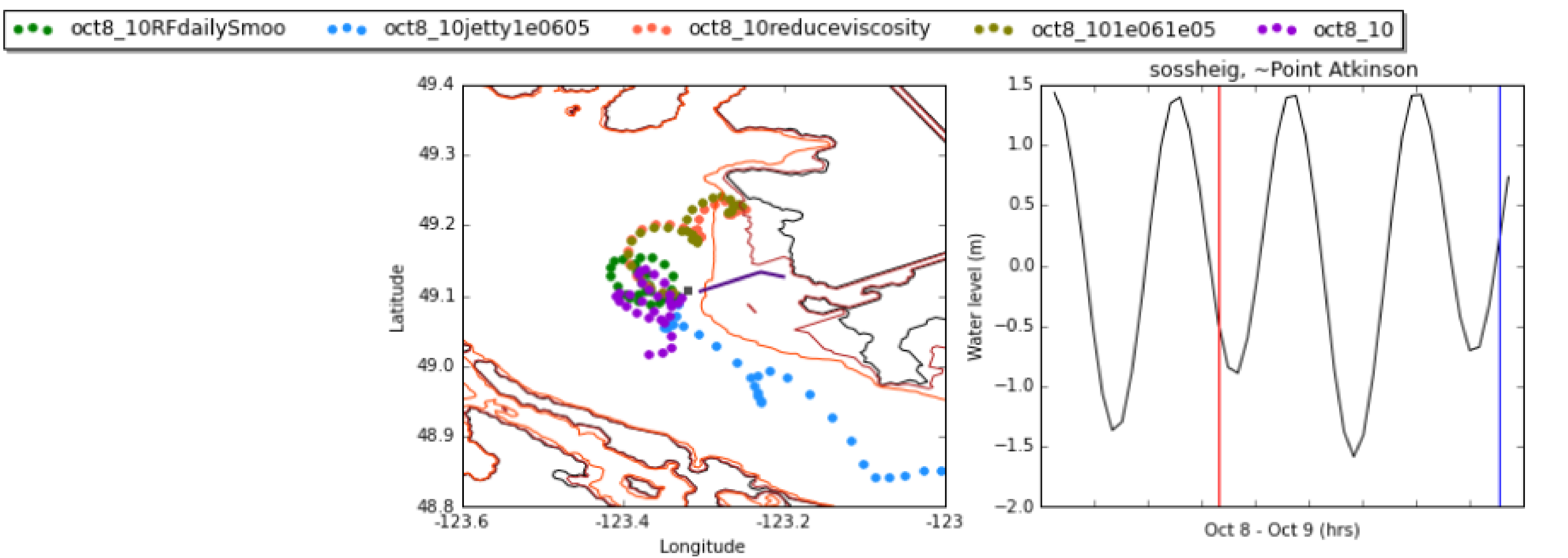




Hindcast comparison

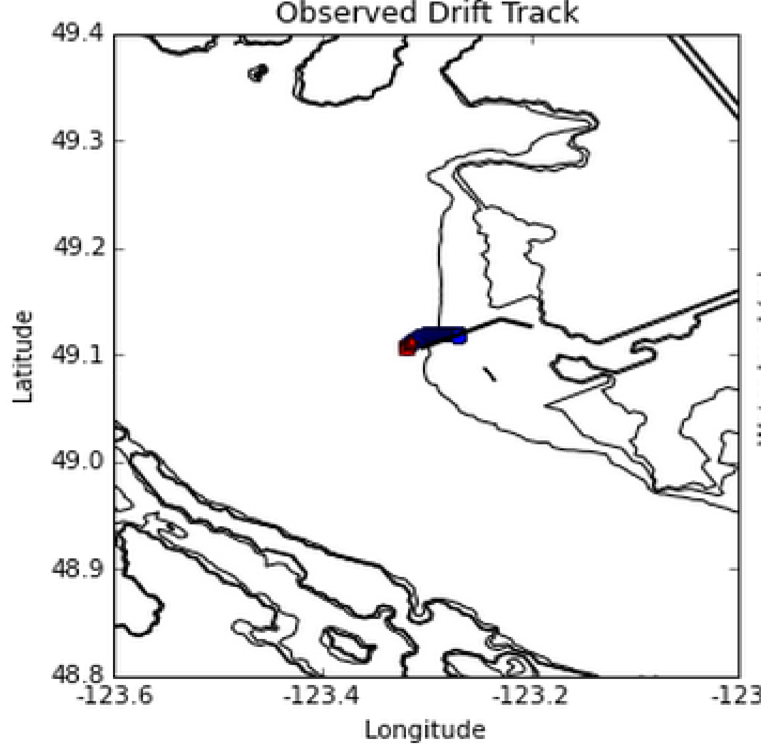
- Drifter2

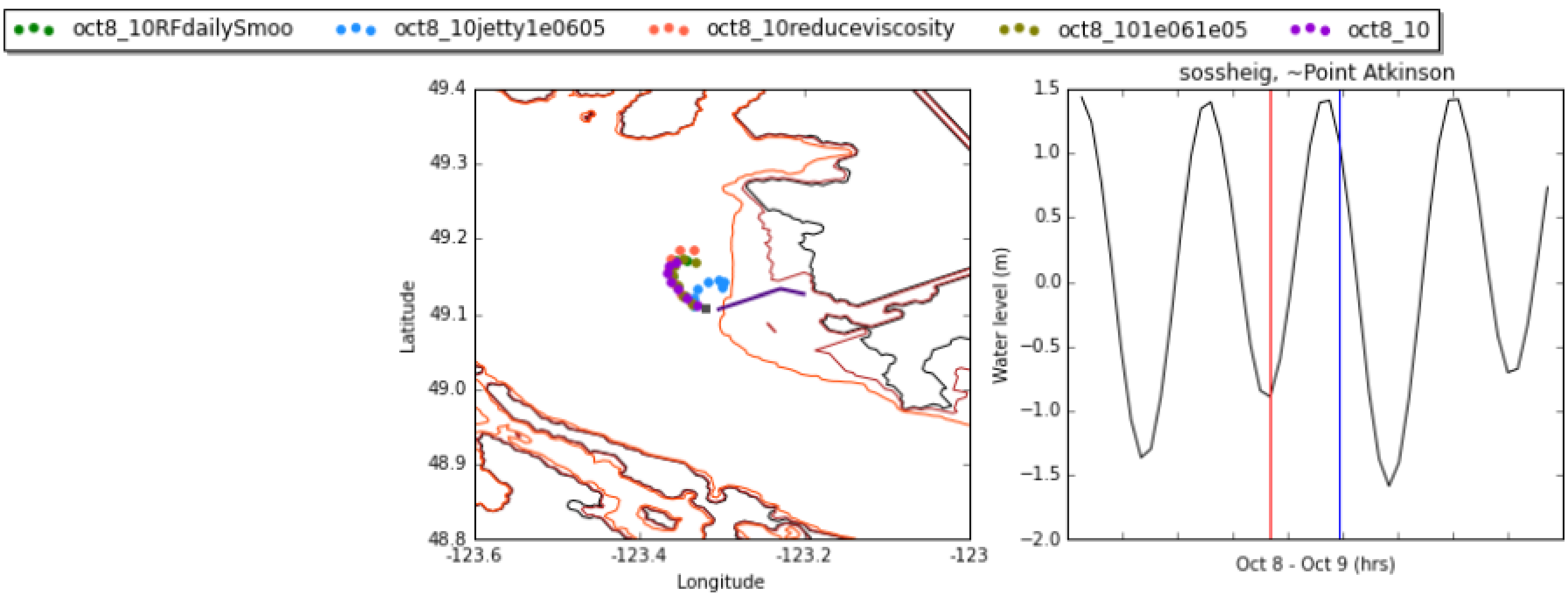




Hindcast comparison

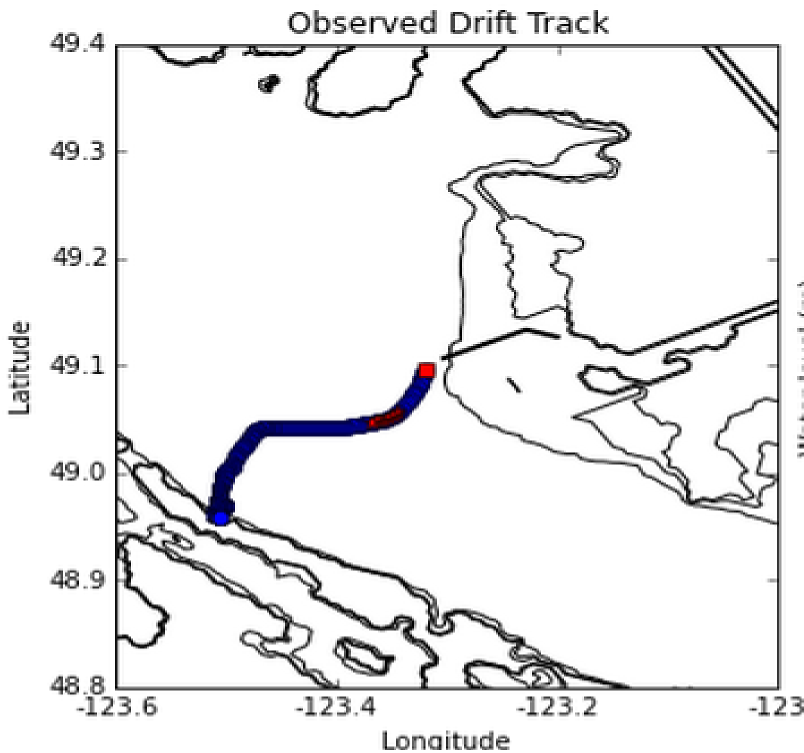
- Drifter3

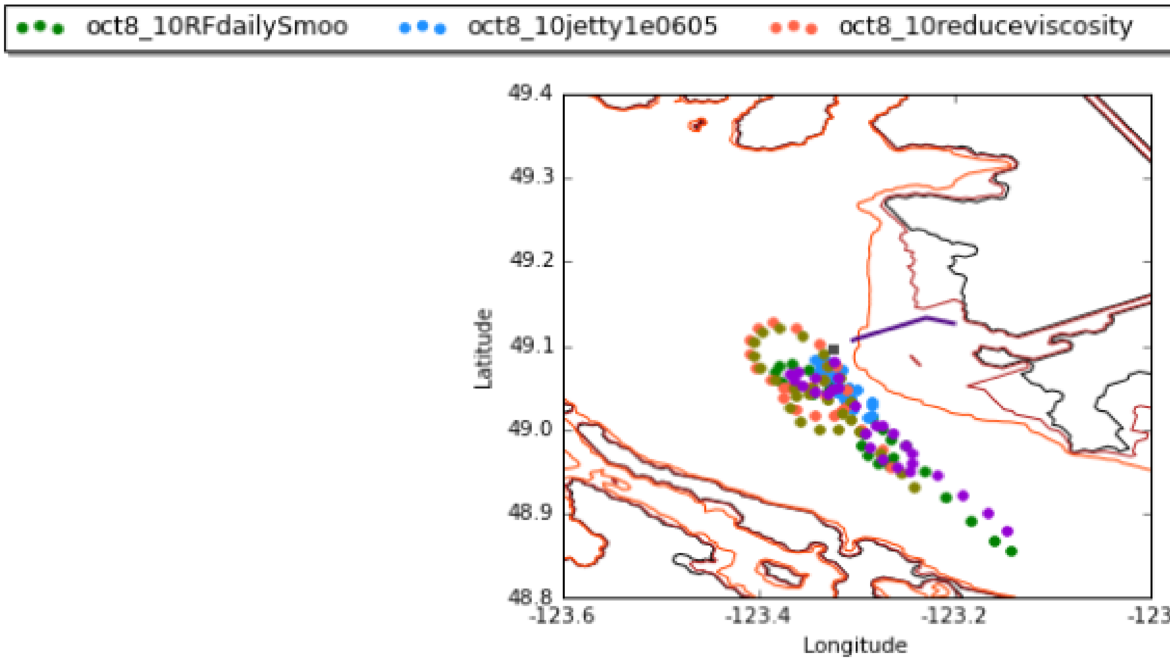


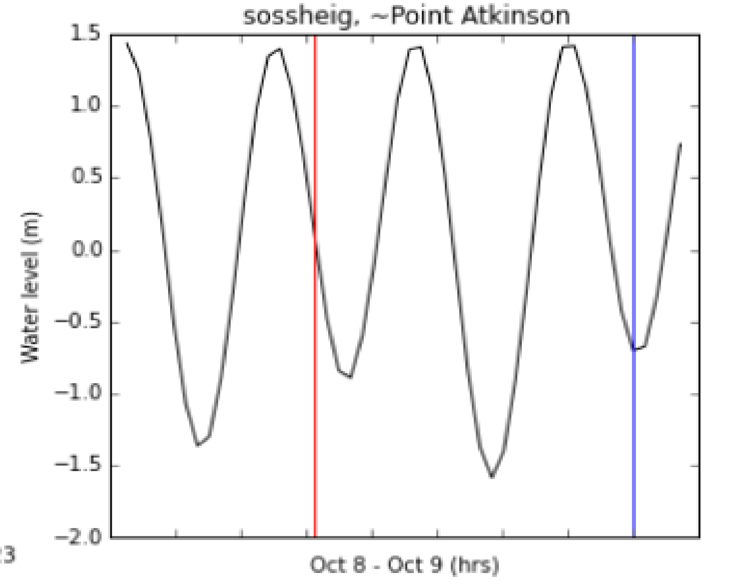


Hindcast comparison

- Drifter4

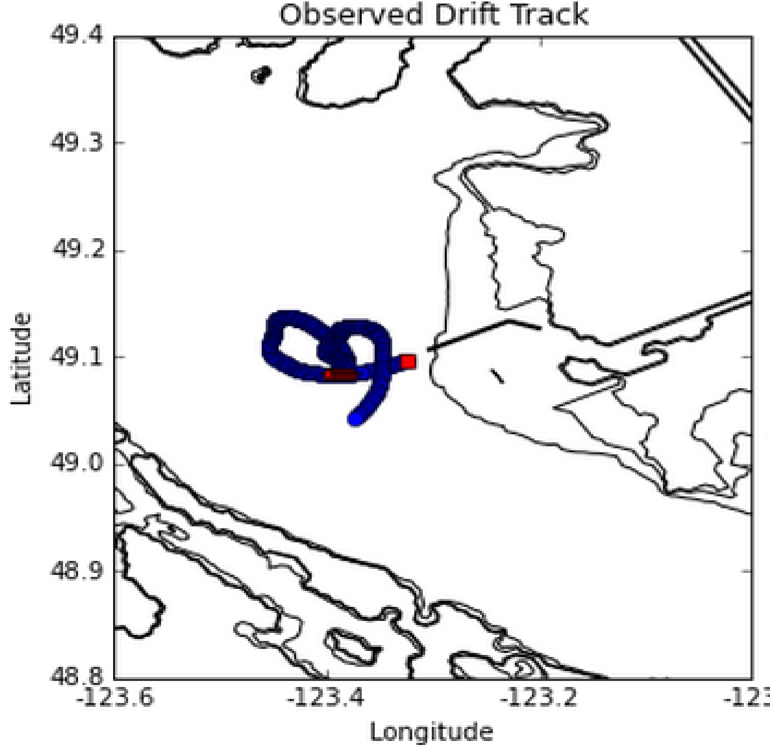


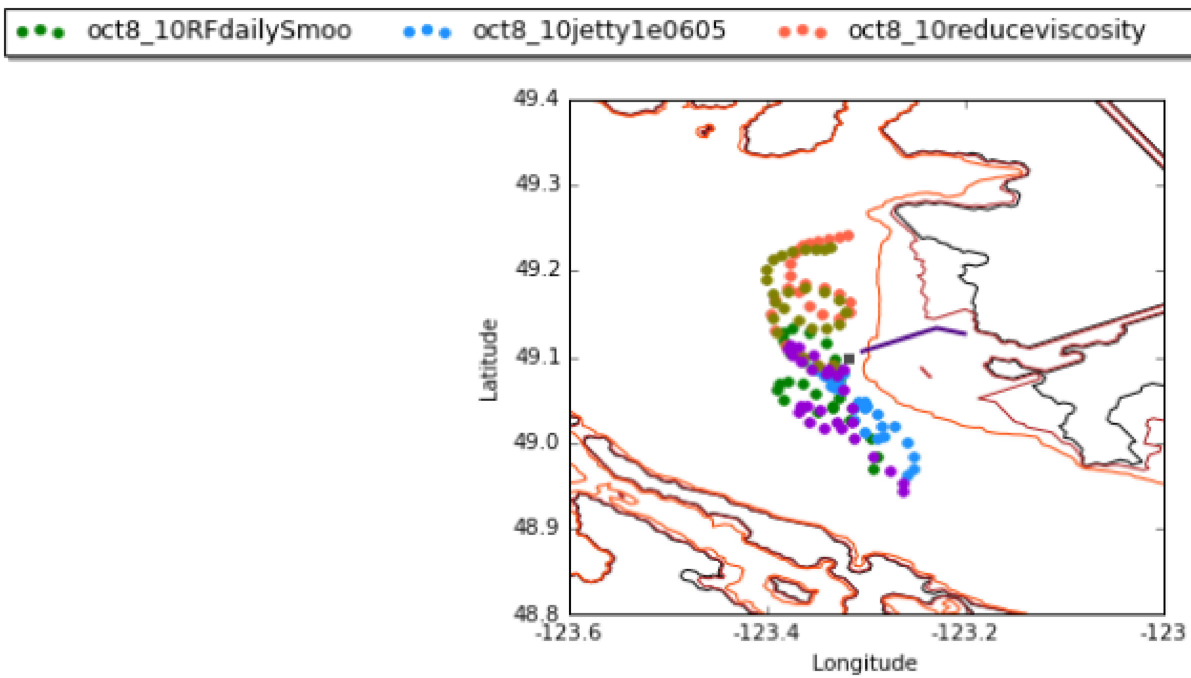


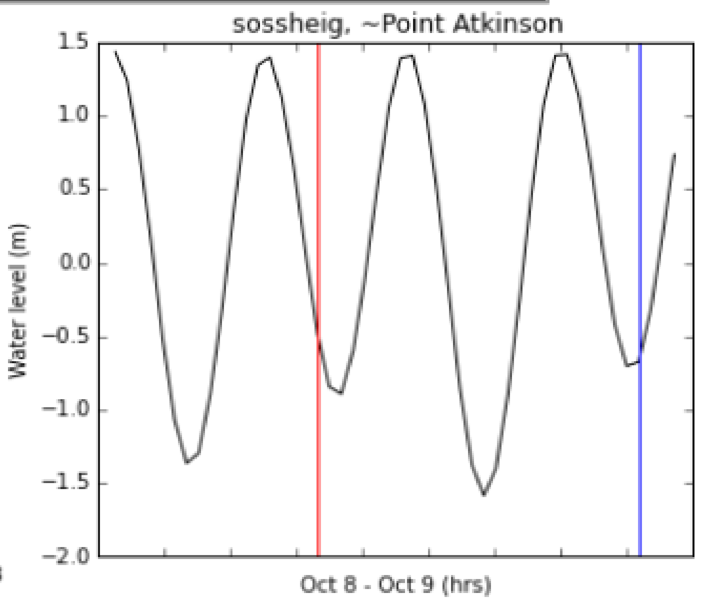


Hindcast comparison

- Drifter5

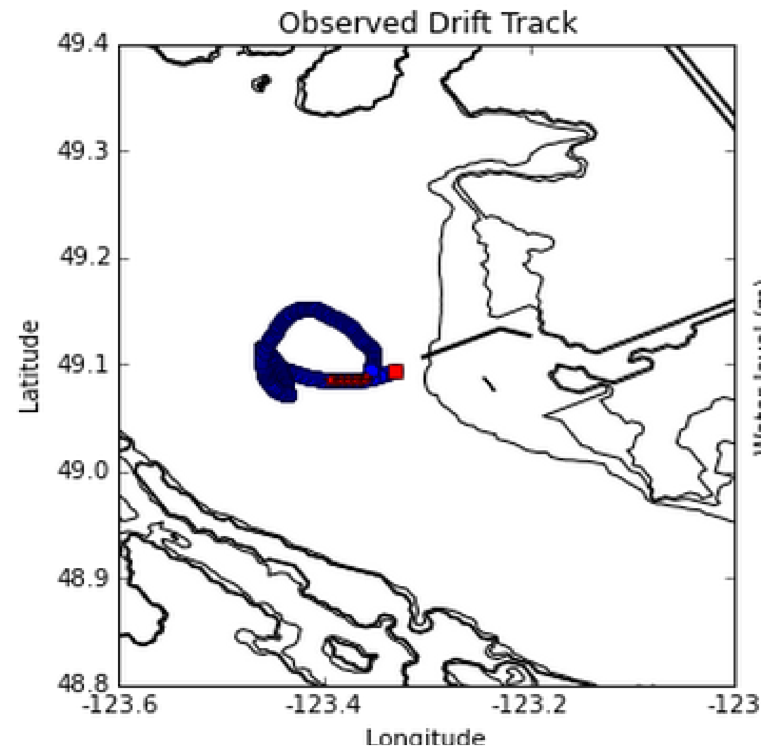


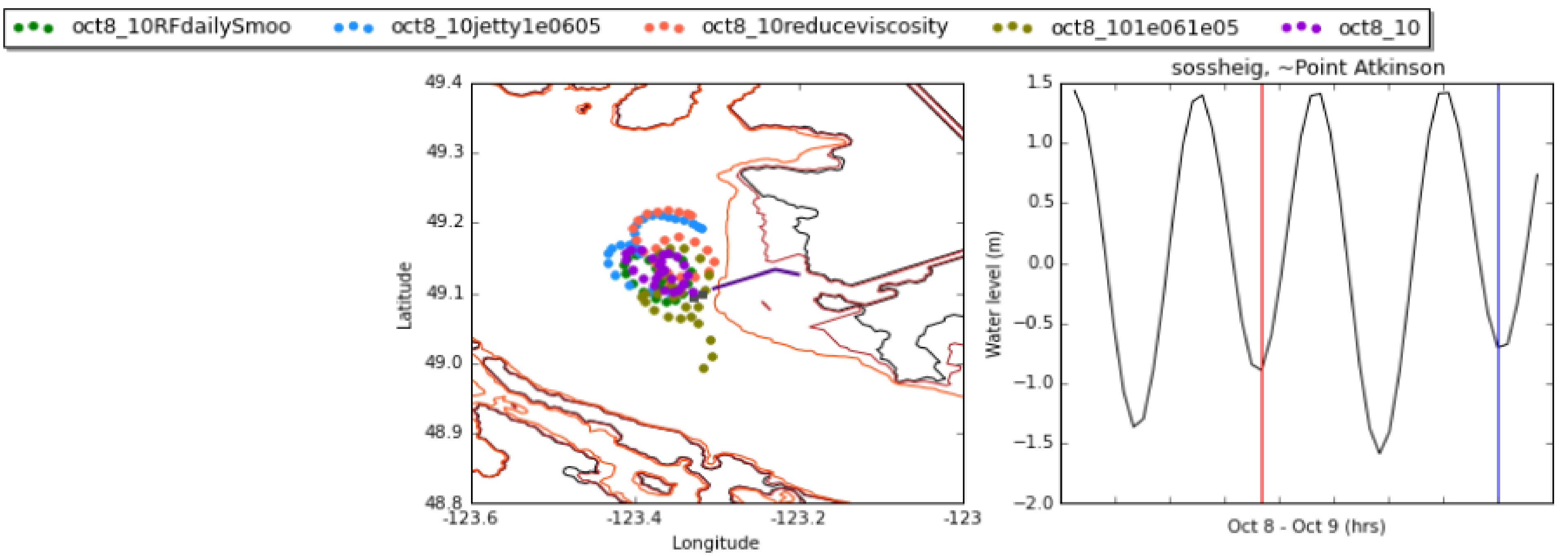




Hindcast comparison

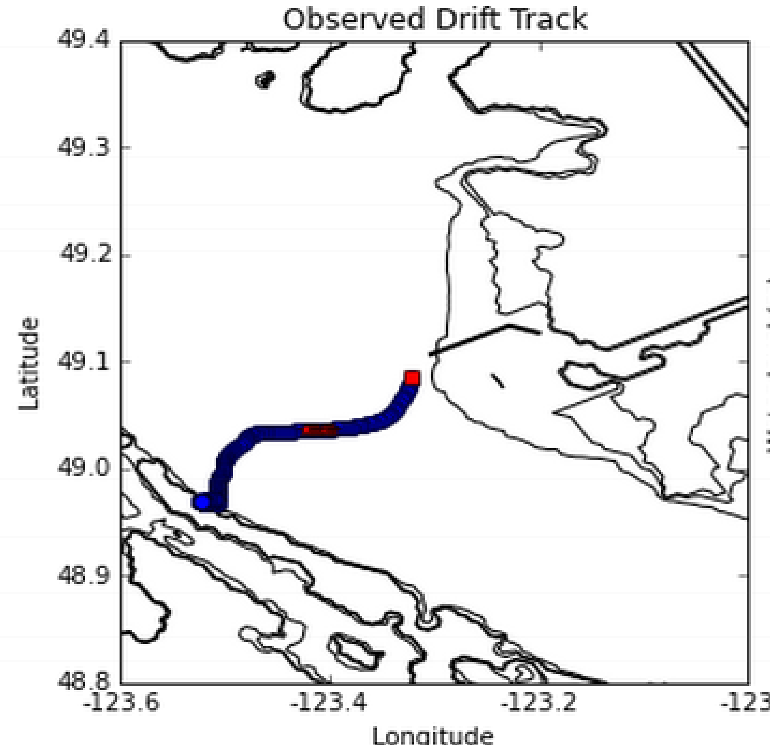
- Drifter6

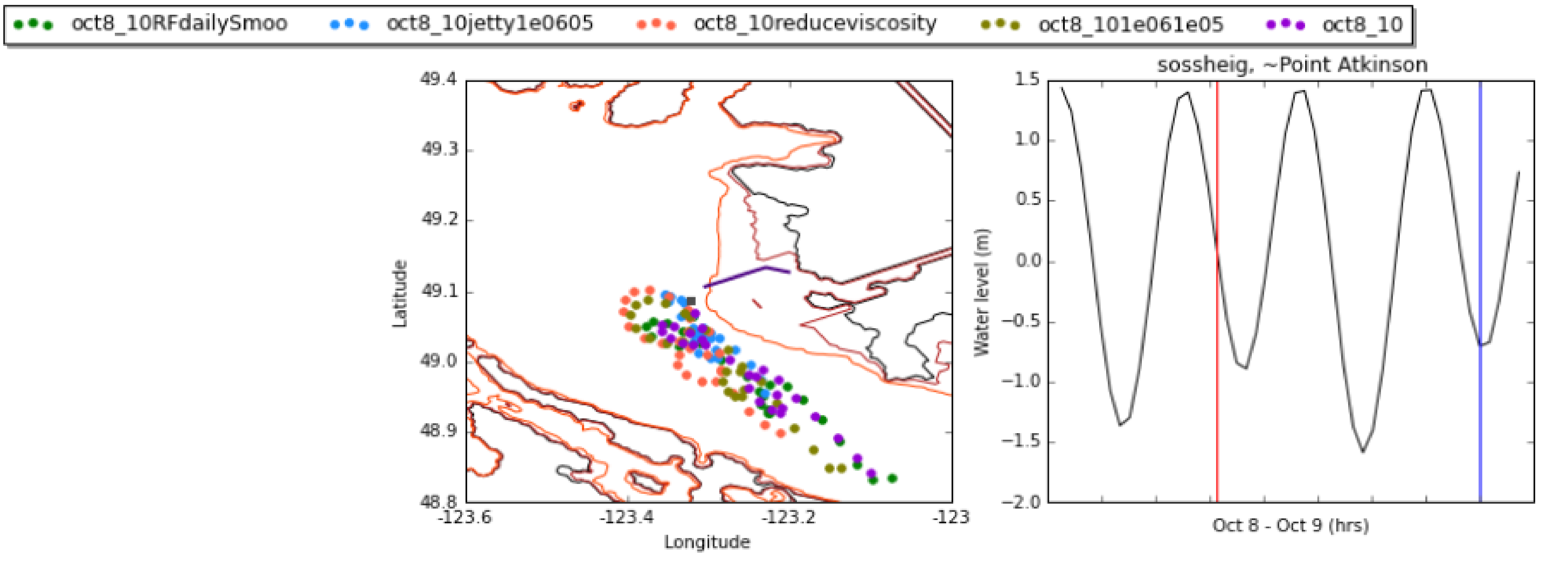




Hindcast comparison

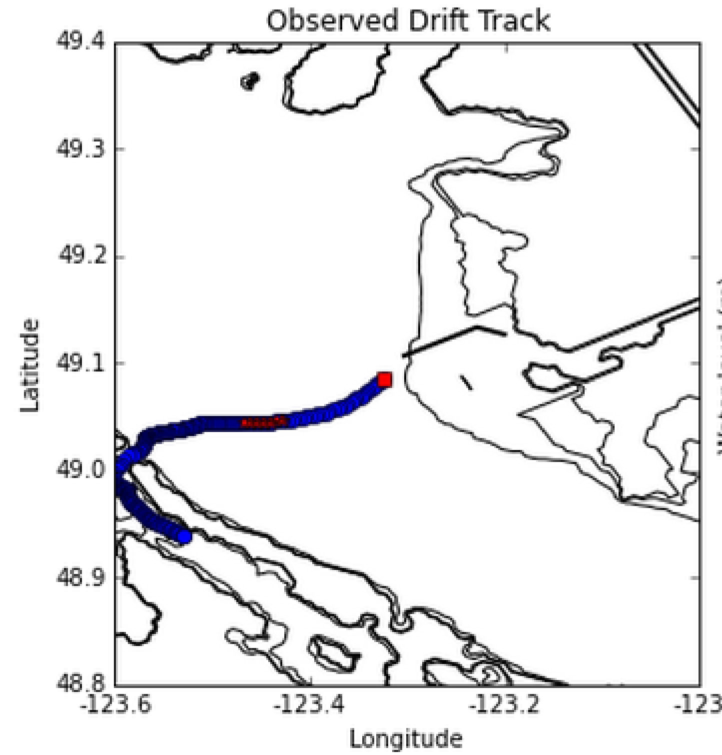
- Drifter7

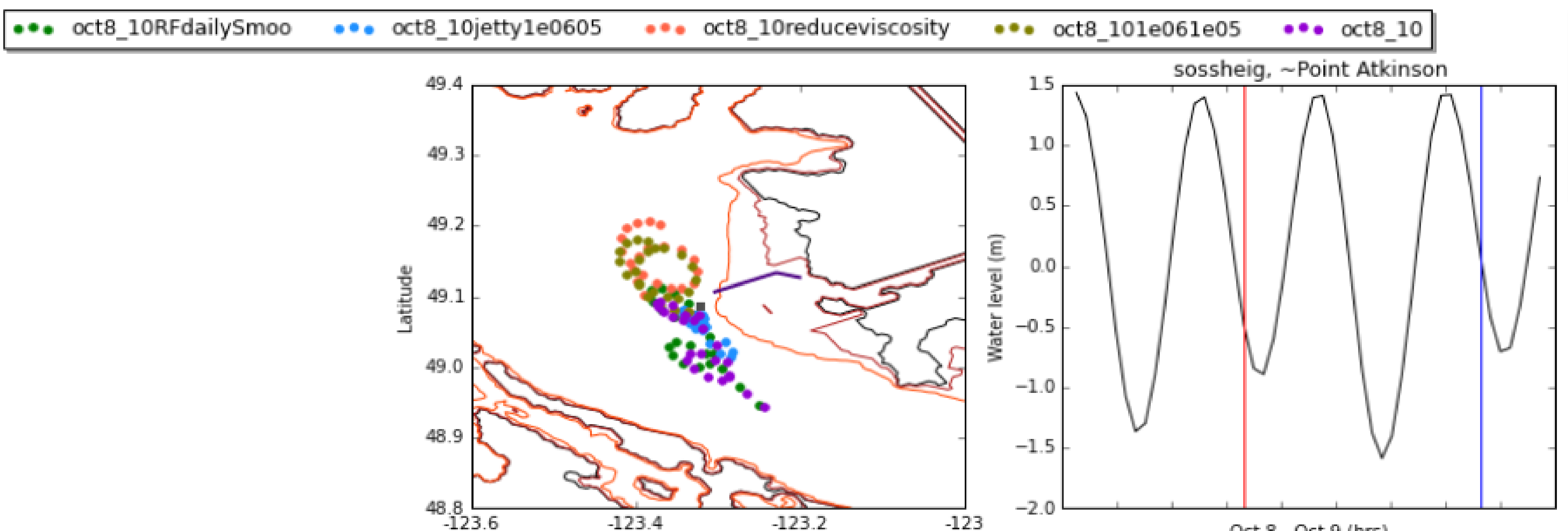




Hindcast comparison

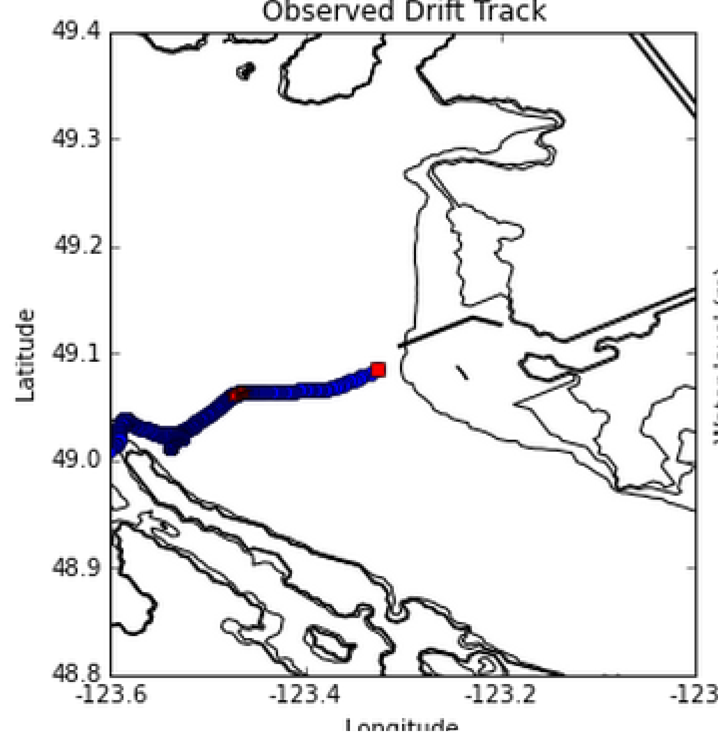
- Drifter8

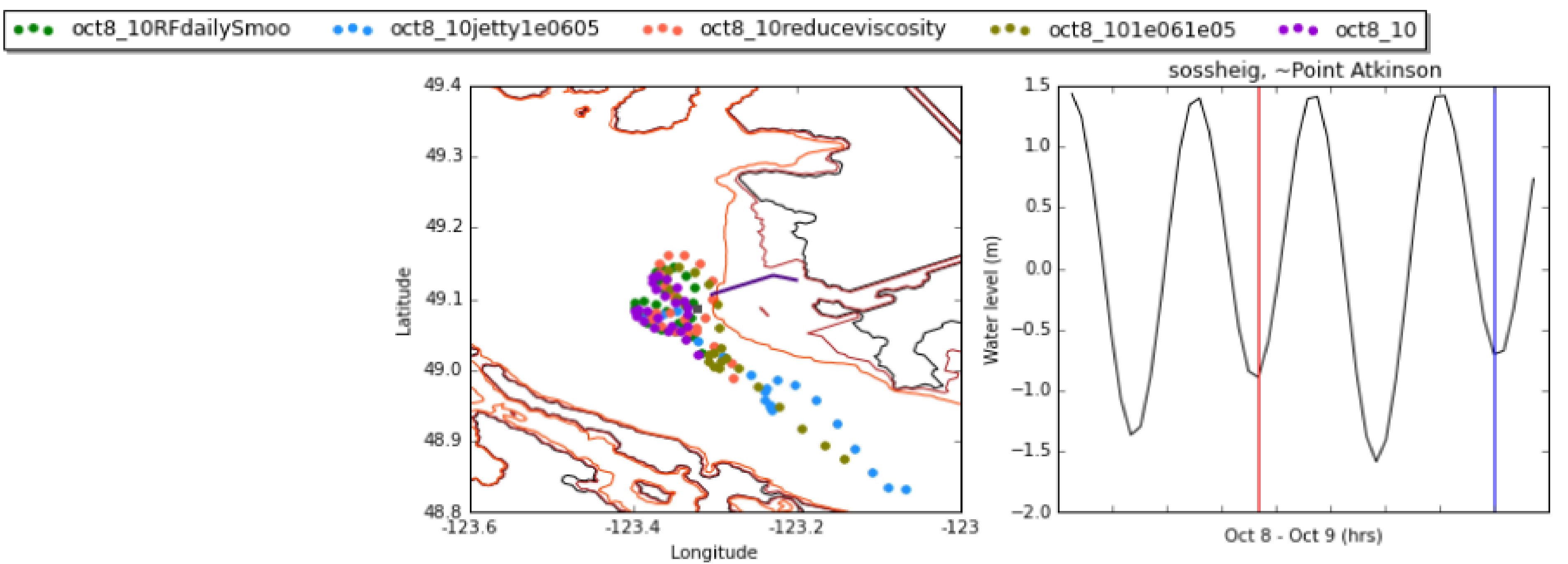




Hindcast comparison

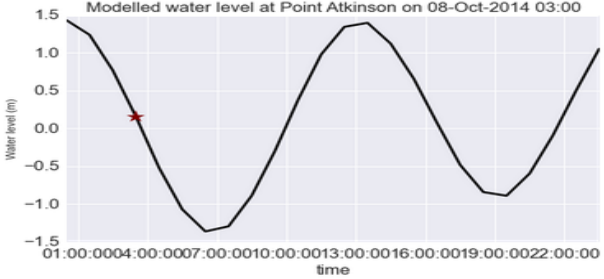
- Drifter9

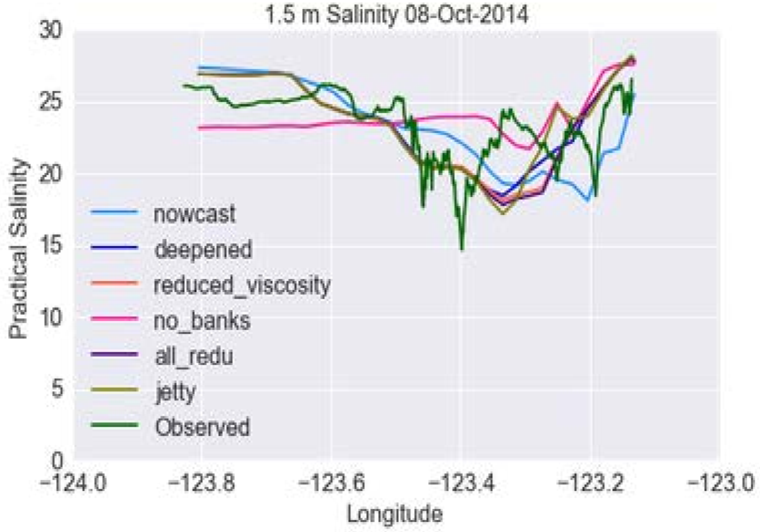


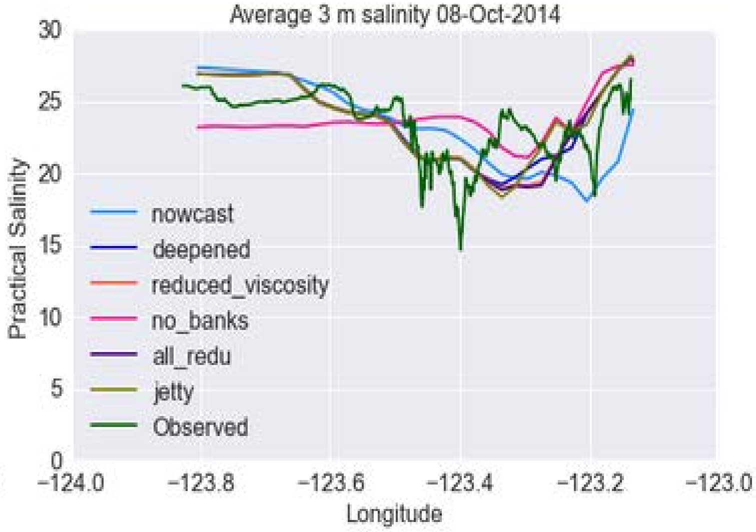


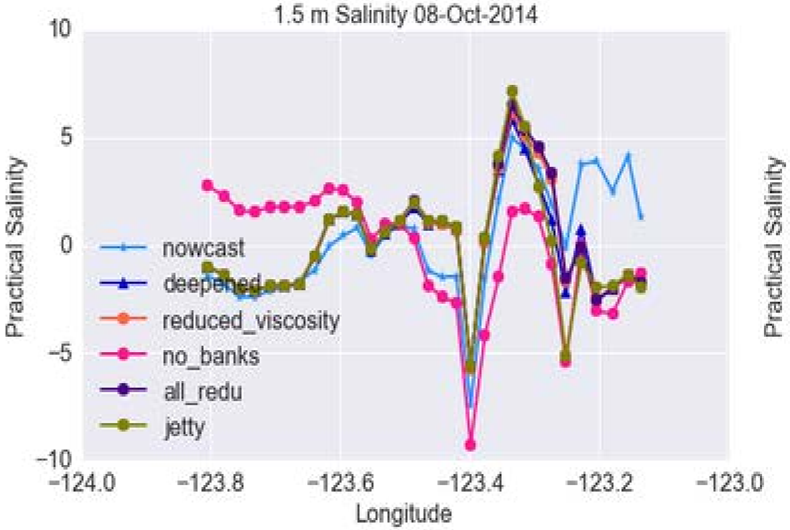
Hindcast comparison

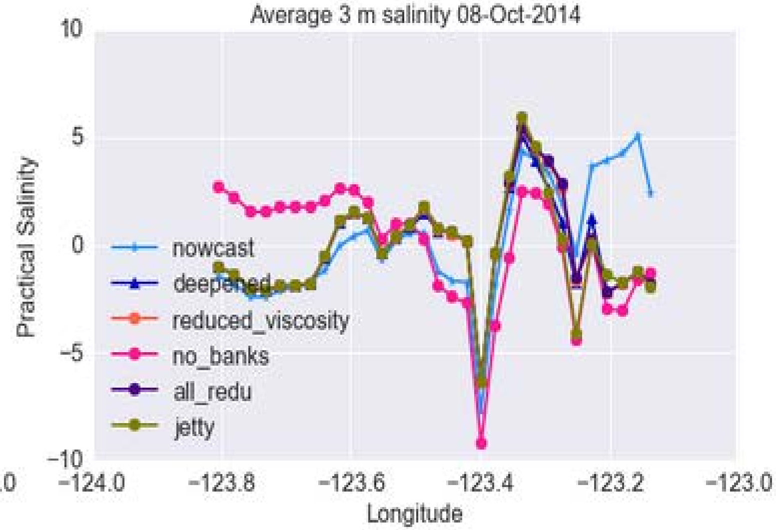
- Comparison with ferry data











Summary

- What kind of available data, of what time scale and space scale, can be used to evaluate plume results? How well does the model reproduce the results?
Ferry-based observational data, CTD profilers, drifters, CODAR data. Surface salinity is in appropriate range, intermediate water is too fresh. Cross-strait flow is too weak and tides are too strong at the surface layer.

- What is the geometry of the Fraser River that should be added into the NEMO model and how sensitive are salinity and surface currents in the plume to the geometry of Fraser River estuary and region around mouth?
By refering to the chart to make topography of Fraser River estuary as realistic as possible. Geometry around the mouth affect much on the barotropic tides in the Fraser, added jetty blocks some northward flow right at river mouth.

- How do different parameters affect the plume properties?
Vertical eddy viscosity and diffusivity are two important parameters for mixing in the plume. By reducing viscosity, plume can go further offshore.

Future work

- How well are the mean currents represented by the model? By comparing the mean currents of model results with CODAR data.

- How do plume properties vary in different temporal scales and to what degree of importance of each forcing on the mixing of the plume. By performing simulation during freshet and non-freshet period, say, a month, without forcing(only river forcing), without coriolis force, only tides, only wind, and combine all of them respectively, to compare the plume patterns with observations. Another option is to use tidally averaged, volume-integrated energy budget method to determine the relatively importance of each forcing factor.

Thank you！